

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXXIII.

February 14, 1873.

No. 4.

PROFESSOR CAYLEY, F.R.S., President, in the Chair.

Carl Behrens, Esq., Durban, Natal,
 Ernest Carpmael, Esq., St. John's College, Cambridge,
 Harris Hills, Esq., Feering House, Kelvedon, Essex,
 Wm. J. Lewis, Esq., Oriel College, Oxford,
 Adolph Lindemann, Esq., 3 Great George Street, Westminster,
 D. A. Marsden, Esq., 65 Lincoln's Inn Fields; and
 Edmund Neison, Esq., 37 Fellowes Road, N.W.,

were balloted for and duly elected Fellows of the Society.

Report of the Council to the Fifty-third Annual General Meeting of the Society.

Progress and present state of the Society:—

	Compounders.	Annual Contributors.	Non-residents.	Patroness, and Honorary.	Total Fellows.	Associates.	Grand Total.
December 31, 1871	192	304	9	3	508	44	552
Since elected ...	+ 5	+ 26	...	...	...	+ 8	...
Deceased	— 6	— 2	...	— 1	...	— 4	...
Removals	+ 2	— 2	...	...	...	...	...
Resigned	...	— 5	...	...	...	...	...
Dec. 31, 1872 ...	193	321	9	2	525	48	573

Mr. Whitbread's Account as Treasurer of the Ro

		RECEIPTS.		£	s.	d.	£	s.
1872.	Balance of last year's account	...	..				271	13
Jan. 6	By Dividend on £3400 Consols	...	...	49	14	6		
Apr. 6	By ditto on £5200 New 3 per Cents	...	...	76	1	0		
July 6	By ditto on £3600 Consols	...	...	53	2	0		
Oct. 7	By ditto on £5200 New 3 per Cents	...	...	76	14	0		
							255	11
	Received for arrears of contributions	...		188	19			
	Annual contributions	...	...	388	10			
	28 Admission-fees	...	...	58	16			
	First years' contributions	...	...	44	2			
							680	7
	8 compositions	...	...				168	0
	Sale of publications:—							
	At the Rooms of the Society	...	...	10	6	0		
	By Messrs. Williams and Norgate	...	...	19	16	5		
							30	2

 £1405 14

Astronomical Society, from January 1 to December 31, 1872.

EXPENDITURE.

Salaries:—				£	s.	d.	£	s.	d.
Editor of Monthly Notices	...	...	...	60	0	0			
Assistant Secretary	...	...	...	130	0	0			
Commission on Collecting	...	...	...	34	9	0			
							224	9	0
Taxes:—									
Land and Assessed	...	...	...	7	1	3			
Income	...	...	...	2	16	6			
Poor Rate	...	...	...	10	19	4			
Other Parish Rates	...	...	...	6	5	4			
							27	2	5
Bills:—									
Strangeways, printer	...	...	...	320	3	6			
Metcalf, engraving	...	...	...	3	13	6			
Taylor & Co. „	...	...	...	2	13	6			
Wesley, „	...	...	...	9	8	6			
Rumfitt, bookbinder	...	...	...	17	3	9			
Sun Fire Office Insurance	...	...	...	7	15	6			
Browning, instrument-maker	...	...	...	1	4	6			
Grubb, „	...	...	...	5	0	0			
Rev. C. Pritchard, for Sir J. Herschel's Catalogue	...	...	...	35	0	0			
Banks & Barry, plans	...	...	...	4	4	0			
W. Day, gratuity	...	...	...	5	0	0			
							411	6	9
Miscellaneous items:—									
House expenses	...	...	...	22	3	2			
Stamps and postages	...	...	...	40	11	1			
Books and parcels	...	...	...	5	9	9			
Expenses of evening meetings	...	...	...	17	10	0			
Coals and wood	...	...	...	12	0	0			
Gas	...	...	...	6	1	6			
Sundries	...	...	...	14	10	7			
Turnor Fund	...	...	...	0	11	0			
							118	17	1
Mrs. Jackson Gwilt's annuity, 1 year	...	...	...				8	15	10
							790	11	1
Investment:—									
Purchase of £200 Consols at 93	...	...	...				186	5	0
Cheque book and banker's commission	...	...	...				0	10	5
							977	6	6
Balance at Banker's	...	...	...				428	8	0
							£1405	14	6

Examined and found correct, Jan. 25, 1873,

(Signed)

H. PERIGAL,

W. T. LYNN,

ROBT. J. LECKY,

} *Auditors.*

Assets and Present Property of the Society, January 1, 1873:—

					£	s.	d.	£	s.	d.
Balance at Banker's	...	...	...	...	...	...	...	428	8	0
3 Contributions of 8 years' standing	...	...	...	...	50	8	0			
2	"	7	"	...	29	8	0			
9	"	6	"	...	113	12	0			
4	"	5	"	...	42	0	0			
5	"	4	"	...	42	0	0			
6	"	3	"	...	37	16	0			
26	"	2	"	...	109	4	0			
47	"	1	"	...	98	14	0			
Balances of several Accounts	...	...	...	...	21	7	0			

544 9 0

Due for Publications
 £5200 New 3 Per Cents (including Mrs. Jackson Gwilt's Gift, £300).

17 10 0

£3600 Consols, including the Lee Fund (£100) and Turnor Fund (£500).

Unsold Publications of the Society.

Various astronomical instruments, books, prints, &c.

Balance of Turnor Fund (included in Treasurer's Account)

182 12 9

Stock of volumes of the *Memoirs*:—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	8	XIV.	387	XXIX.	444
I. Part 2	48	XV.	170	XXX.	294
II. Part 1	66	XVI.	195	XXXI.	170
II. Part 2	30	XVII.	168	XXXII.	200
III. Part 1	82	XVIII.	173	XXXIII.	204
III. Part 2	101	XIX.	179	XXXIV.	189
IV. Part 1	99	XX.	176	XXXV.	161
IV. Part 2	101	XXI. Part 1	216	XXXVI.	247
V.	121	XXI. Part 2	100	(with M. N.)	
VI.	147	XXI.	86	XXXVI.	24
VII.	172	(together).		(without)	
VIII.	158	XXII.	179	XXXVII.	325
IX.	161	XXIII.	173	Part 1	
X.	171	XXIV.	179	XXXVII.	345
XI.	161	XXV.	193	Part 2	
XII.	186	XXVI.	197	XXXVIII.	358
XIII.	195	XXVII.	453	XXXIX.	414
		XXVIII.	412	Part 1	
				XXXIX.	472
				Part 2.	

The instruments belonging to the Society are as follows:—

The *Harrison* clock,
 The *Owen* portable circle,
 The *Beaufoy* circle,
 The *Beaufoy* transit,
 The *Herschelian* 7-foot telescope,
 The *Greig* universal instrument,
 The *Smeaton* equatoreal,
 The *Cavendish* apparatus,
 The 7-foot *Gregorian* telescope (late Mr. Shearman's),
 The *Variation* transit (late Mr. Shearman's),
 The *Universal* quadrant by *Abraham Sharp*,
 The *Fuller* theodolite,
 The *Standard* scale,
 The *Beaufoy* clock, No. 1,
 The *Beaufoy* clock, No. 2,
 The *Wollaston* telescope,
 The *Lee* circle,
 The *Sharpe* reflecting circle,
 The *Brisbane* circle,
 The *Baker* universal equatoreal,
 The *Reade* transit.

The *Sheepshanks'* collection of instruments, viz.,—

1. 30-inch transit, by *Simms*, with level and two iron stands.
2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.
3. $4\frac{6}{10}$ -inch achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters, with equatorial stand and clock movement.
4. $3\frac{1}{4}$ -inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
5. $2\frac{3}{4}$ -inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
6. $2\frac{3}{4}$ -inch achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.
7. 2-foot navy telescope.
8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.
9. Repeating theodolite, by *Ertel*, with folding tripod stand.
10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.
11. Portable zenith instrument, with detached micrometer and eyepiece.

12. 18-inch Borda's repeating circle, by Troughton.
13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.
14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff, in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.
15. Level collimator, plain diaphragm.
16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.
17. Hassler's reflecting circle, by Troughton, with counterpoise stand.
18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.
19. 5-inch reflecting circle, by Lenoir.
20. Reflecting circle, by Jecker, of Paris.
21. Box sextant and 3-inch plane artificial horizon.
22. Prismatic compass.
23. Mountain barometer.
24. Prismatic compass.
25. 5-inch compass.
26. Dipping needle.
27. Intensity needle.
28. Ditto ditto.
29. Box of magnetic apparatus.
30. Hassler's reflecting circle, with artificial horizon roof.
31. Box sextant and $2\frac{1}{4}$ -inch glass plane artificial horizon.
32. Plane speculum artificial horizon and stand.
33. $2\frac{1}{2}$ -inch circular level horizon, by Dollond.
34. Artificial horizon roof and trough.
35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.
36. A pentagraph.
37. A noddy.
38. A small Galilean telescope, with the object lens of rock-crystal.
39. Six levels, various.
40. 18-inch celestial globe.
41. Varley stand for telescope.
42. Thermometer.
43. Telescope, with the object-glass of rock crystal.

To these must be added the following instruments which had been employed in the Observations of the Total Solar Eclipse of 1870, and which, by a resolution of the joint Eclipse Committee of 1870, were transferred to the Royal Astronomical Society:—

Portable equatoreal stand,
 Portable altazimuth tripod,
 Four polarimeters,
 Two Biquartz and Nicol's prisms,
 Registering spectroscope, with prism,
 Camera and chemicals, in box,
 Two five-prism spectroscopes,
 Cradle for telescope,
 Eight-inch reflector and stand,
 Spectroscope,
 A small box, containing—
 Three square-headed Nicol's prisms,
 Two Babinet's compensators,
 Two double-image prisms,
 Three Savarts,
 One positive eye-piece, with Nicol's prism,
 One dark wedge.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of the Council, to the several parties under mentioned, viz.:—

The *Fuller* theodolite, to the Director of the Sydney Observatory.

The *Beaufoy* transit, to the Observatory, Kingston, Canada.

The *Sheepshanks* instrument, No. 1, to Mr. Lassell.

Ditto ditto No. 2, to Mr. Huggins.

Ditto ditto No. 4, to Rev. C. Lowndes.

Ditto ditto No. 5, to Mr. Birt.

Ditto ditto No. 6, to the late Rev. J. Cape.

Ditto ditto No. 8, to Rev. C. Pritchard.

Ditto ditto No. 9, to the Director of the
Sydney Observatory.

Ditto ditto No. 41, to Rev. C. Pritchard.

Ditto ditto No. 43, to Mr. Huggins.

The 6-inch circular protractor, to Mr. Birt.

Tripod stand. Mr. Chambers.

Lent on account of the Eclipse Expedition:—

One polarimeter. Mr. Ranyard.

One ditto. B. A. Eclipse Committee.

One Biquartz and Nicol's prism. Mr. Ranyard.

Camera and chemicals, in box. B. A. Eclipse Committee.

One five-prism spectroscope. B. A. Eclipse Committee.

One ditto. Mr. Lockyer.

Cradle for telescope. Mr. W. A. Harris.

PRINTED TRANSACTIONS OF THE SOCIETY.

Memoirs.

Part II. of Volume XXXIX. of the *Memoirs* has been published. This part which is paged in continuation of Part I. contains four *Memoirs*.

1. "Les Variations de la Pesanteur dans les Provinces Occidentales de l'Empire Russe." Par A. Sawitsch.

2. "On the Geodesic Lines on an Ellipsoid." By Professor Cayley, F.R.S.

3. "The Second Part of a Memoir on the Development of the Disturbing Function in the Lunar and Planetary Theories." By Prof. Cayley, F.R.S.

This paper is a sequel to a memoir published in Volume XXVIII. of the Society's *Memoirs*, and Prof. Cayley has therefore entitled it as above, but it, in fact, has reference only to the Planetary Theory.

4. "On the Law of Facility of Errors of Observations, and on the Method of Least Squares." By J. W. L. Glaisher, Esq., B.A.

Monthly Notices.

Some very important Papers have appeared in the *Monthly Notices* since the last Annual Report. Formerly, some of these would have been considered appropriate for insertion in the Volume of *Memoirs*. By placing them, however, in the Octavo Volume, an early publication is secured to the author, and consequently the results of any new research are laid before our home and foreign astronomers, without the delay which must necessarily arise when the Paper is reserved for the *Memoirs*. A few of the principal Papers printed in the *Monthly Notices* are made the subjects for special remark in another section of the Report.

The Council take this opportunity of drawing the attention of the Fellows to the great importance of recording in any Paper intended for publication in the *Monthly Notices*, full particulars of the telescope or instrument employed, together with any fact which might have an effect upon the observations. In most of the reports of astronomical observations which have been made to the Society, there has been an absence of sufficient detail, or enumeration of the circumstances under which the observations have been made, and hence much of their value is lost. The Council therefore recommend to the notice of those Fellows, or other gentlemen, who may favour them with such communications in future, the following suggestions in relation to them,—

When they are the results of telescopic observation, they should be accompanied by the following particulars. The form of telescope used should be stated—its aperture and focal length,—whether equatorially mounted or not, and the magnifying powers employed. If a drawing is sent—the result of a single

observation—the Greenwich or local time should be given with more or less accuracy, as well as the apparent clearness of atmosphere and state of the sky. If the result of a series of observations, some at least of the most remarkable should be selected, and the times, circumstances, and conditions of atmosphere when they were severally made, should be fully stated. If these particulars be generally noted and communicated, the value of such contributions will be greatly enhanced.

The Council, having duly considered that it would be for the interests of astronomy, and of the Society to distribute freely the Proceedings to non-members at a small charge, have resolved that in future the *Monthly Notices* may be obtained by application to the Assistant-Secretary, at the price of one shilling for each number, or ten shillings for the session, which in the latter instance includes the postage within the limits of the United Kingdom.

Government Aid to the Cultivation of the Physics of Astronomy.

After long and careful consideration of this subject, extending over four meetings, two of which were especially convened for the purpose, and including the discussion of points importantly affecting as well the interests of science as the dignity of this Society, your Council by a large majority passed the following resolutions on the 28th of June, 1872:—

1. That the President be authorised, on behalf of the Council and Fellows of the Royal Astronomical Society, to bring before the Royal Commissioners on Scientific Instruction and on the Advancement of Science now sitting, the importance of further aid being afforded to the cultivation of the Physics of Astronomy.

2. They think such aid would be most effectually given by increased assistance, where needed, to existing Public Observatories, in the direction recommended by the heads of those Observatories, especially that at the Cape of Good Hope, and by the establishment of a new Observatory on the Highlands of India, or in some other part of the British dominions where the climate is favourable for the use of large instruments.

3. The Council do not recommend the establishment of an independent Government Observatory for the cultivation of Astronomical Physics in England, especially as they have been informed that the Board of Visitors of the Royal Observatory at Greenwich, at their recent meeting, recommended the taking of photographic and spectroscopic records of the Sun at that Observatory.

OBITUARY.

The deaths of the following Fellows and Associates have been reported to the Council since the last Anniversary,—

Honorary Member :—Mrs. Mary Somerville.

Fellows:—Joseph Bateman, Esq., LL.D.
Nathaniel Beardmore, Esq.
Rev. Jonathan Cape, F.R.S.
Benjamin Godfrey, Esq., M.D.
Richard Hodgson, Esq.
Capt. Ebenezer Little.
Prof. Adam Sedgwick, LL.D., F.R.S.
S. H. Wright, Esq.

Associates:—M. Charles E. Delaunay.
Prof. F. Kaiser.
M. Paul A. E. Laugier.
Prof. F. M. Schwerd.

MARY SOMERVILLE (*née* FAIRFAX) was born at Jedburgh on December 26, 1780, and died on November 30, 1872, at Naples, aged nearly ninety-two years. In considering her education, we have not to mention important seminaries, where skilled teachers make it their chief business to impart to others the knowledge for which they are themselves eminent, but to speak only of studies pursued in the calm of a quiet home. This, rightly understood, is perhaps the most remarkable feature of her career. There are few mathematicians so eminent as she deservedly was, in whose fame great public schools and universities do not in some degree partake. But we owe almost to accident the discovery of the powers of Mary Fairfax's mind, while the gradual development of those powers proceeded under the guidance of tutors unknown to fame, and with access only to such assistance as could be given by the friends of her own family.

Mrs. Somerville has herself described how it chanced that the peculiar powers of her mind came first to be recognised. She was in the habit of working at her needle in the window-seat, while her brother took his lessons in geometry and arithmetic. Fortunately (in her case) the work which is regarded as most suitable to the capacity of women leaves the mind unoccupied; and consequently there was nothing to prevent Mary Fairfax from attending to the lessons intended for her brother. She gradually became interested in the subject of these lessons, and took care not only to be present regularly, but to study her brother's books in her own room. It happened that, on one occasion, young Fairfax failed to answer a question addressed to him, and his sister involuntarily prompted him. The tutor was naturally surprised that the quiet Mary Fairfax should have any ideas beyond the needlework which had apparently engaged her attention; but, being a sensible man, he was at the pains to ascertain the degree and soundness of her knowledge; and, finding that she had really grasped the first principles of mathematics, he "took care that she should have liberty to go on in her own way." If a boy had shown similar fitness for mathema-

tical research, anxious attention would have been devoted to the choice of books and teachers, school and university; but the case of a girl showing such tastes seemed to be adequately met by according to her the privilege of following her own devices. We shall never know certainly, though it may be that hereafter we shall be able to guess, what science lost through the all but utter neglect of the unusual powers of Mary Fairfax's mind. We may rejoice that, through an accident, she was permitted to reach the position she actually attained; but there is scarcely a line of her writings which does not, while showing what she was, suggest thoughts of what she might have been.

While studying mathematics "in her own way," she found a difficulty which for a time threatened to interfere with her progress. She was unable to read the *Principia*, because she could not understand Latin. In this strait, she applied, "after much hesitation," to Prof. Playfair. She asked if a woman might, without impropriety, learn Latin. After ascertaining the purpose which the young lady had in view—possibly in doubt lest she might follow in the steps of Anne Dacier—Prof. Playfair told her that it would not, in his opinion, do her any harm to learn Latin in order to read the *Principia*. It is noteworthy, as having probably a bearing on the course which Mrs. Somerville's reading subsequently took, that Playfair was one of the few in this country who at that time appreciated the methods of the higher mathematical analysis, and had formed a just opinion of their power—"a power, however," as Sir John Herschel well remarks, "which he was content to admire and applaud rather than ready to wield." His excellent review of the *Mécanique Celeste* probably gave (as Herschel suggests) a stronger impulse to the public mind in the direction of the higher analysis than he could have communicated by any researches of his own.

It was not, however, as a mathematician that Mrs. Somerville first became known to the world. A subject of research, exceedingly difficult and only to be pursued successfully under very favourable conditions, was undertaken by her during the life of her first husband, Captain Greig, son of High Admiral Greig of the Russian Navy. She sought to determine by experiment the magnetising influence of the violet rays of the solar spectrum. "It is not surprising," says Sir John Herschel on this subject, "that the feeble though unequivocal indications of magnetism which she undoubtedly obtained should have been regarded by many as insufficient to decide the question at issue." Nevertheless it was justly regarded as a noteworthy achievement that in a climate so unsuitable as ours any success should have been attained in a research of such extreme difficulty. That she achieved, and, what is more, deserved success, will be inferred from the words in which Sir John Herschel indicates his own opinion of the value of her results: "To us," he says, "their evidence appears entitled to considerable weight; but it is more to our immediate purpose to notice the simple and rational

manner in which her experiments were conducted, the absence of needless complication and refinement in their plan, and of unnecessary or costly apparatus in their execution, and the perfect freedom from all pretension or affected embarrassment in their statement."

In 1832 Mrs. Somerville published the work on which, in our opinion, her fame in future years will be held mainly to depend. The *Mechanism of the Heavens* was originally intended to form one of the works published by the Society for the Diffusion of Useful Knowledge, though it soon outgrew the dimensions suited for such a purpose. Indeed, it is remarkable that either Mrs. Somerville herself or Lord Brougham, at whose suggestion the work was undertaken, should suppose it possible to epitomise Laplace's *Magnum Opus*, or so to popularise it as to bring it within the scope of the Society's publications.

It will be well, in weighing the value of the book, to consider it first with reference to the purpose of its author, though a judgment based on that consideration alone would not be a fair one. These, then, are the words in which Mrs. Somerville presents the scope and purpose of her work:—

"A complete acquaintance with physical astronomy can only be attained by those who are well versed in the highest branches of mathematical and mechanical science: such alone can appreciate the extreme beauty of the results, and the means by which these results are obtained. Nevertheless, a sufficient skill in analysis to follow the general outline, to see the mutual dependence of the several parts of the system, and to comprehend by what means some of the most extraordinary conclusions have been arrived at, is within the reach of many who shrink from the task, appalled by difficulties which perhaps are not more formidable than those incident to the study of the elements of every branch of knowledge, and possibly overrating them by not making a sufficient distinction between the degree of mathematical acquirement necessary for making discoveries and that which is requisite for understanding what others have done. That the study of mathematics, and their application to astronomy, are full of interest, will be allowed by all who have devoted their time and attention to these pursuits; and they only can estimate the delight of arriving at truth, whether it be the discovery of a world or of a new property of numbers."

It cannot be doubted that Mrs. Somerville here indicates her belief in the possibility of presenting her subject in a form suited to the capacities of a large number of readers, and to some extent advocates this as her object. Whether she succeeded or failed in this purpose must therefore be the first question to engage our attention. Sir John Herschel considers that she succeeded, "for all those parts of" her subject, at least, which the work "professes to embrace, that is to say, the general exposition of the mechanical principles employed,—the planetary and lunar theories, and those of *Jupiter's* satellites, with the incidental points

naturally arising out of them." With the utmost respect for the authority of one who was so thorough a master of the subject which Mary Somerville endeavoured to popularize, we venture to express a different opinion. We find it impossible to come to any other conclusion than that, as respects the main purpose of her work, Mrs. Somerville failed entirely; though we hasten to qualify this statement by the remark that in our opinion success was altogether impossible. We believe, in fact, that neither Mrs. Somerville nor Sir John Herschel thoroughly apprehended the difficulty of conveying to the general reader clear ideas respecting even the elements of the subjects they severally endeavoured to expound. But we feel bound to add that Mrs. Somerville's failure, inevitable from the very nature of her task, would in any case have been brought about by the manner in which the task was accomplished. It will presently be seen that in saying this, we are, in fact, touching on the most remarkable and distinguishing quality of Mrs. Somerville's mind.

There are two essential requisites in a treatise intended to introduce a difficult subject to general readers. First, there must be a clear apprehension of the position of such readers, of what they can and of what they cannot understand, and of the form in which what is written for them may most usefully be presented. It is not too much to say that if just ideas had been entertained by Mrs. Somerville on this point, the attempt to present the *Mechanism of the Heavens* in a popular form would never have been made. But secondly, it is essential that in any work of the kind, each statement—each sentence, in fact—should be presented in terms so precise as to be absolutely unmistakable. This is not so necessary in advanced treatises,—indeed, it is too well known how large a proportion of our works on advanced science are wanting in strict precision of expression. But it is absolutely necessary in works intended to popularize science. It is a somewhat remarkable circumstance that in the *Mechanism of the Heavens*,—the boldest attempt ever made, perhaps, in this direction,—not only is precision of expression not a notable feature, but, on the contrary, the most striking fault in the work is the inexactness of the language. Even Sir John Herschel, whose perfect familiarity with the subject of the work, would tend to render the fault less striking to him, was nevertheless struck by it: "The most considerable fault we have to find," he wrote, "with the work before us consists in an habitual laxity of language, evidently originating in so complete a familiarity with the quantities concerned as to induce a disregard of the words by which they are designated, but which, to any one less intimately conversant with the actual analytical operations than its author, must infallibly become a source of serious errors, and which, at all events, renders it necessary for the reader to be constantly on his guard."

These words form the penultimate sentence of Sir John Herschel's critique. We have preferred to speak first of the sub-

ject touched on, so as to pass without reservation to a more pleasing topic,—the real and unquestionable value of Mrs. Somerville's chief work. And after all, the good qualities of the work are intrinsic, while its main fault relates to a purpose which the work never could have fulfilled, no matter how carefully the fault had been avoided.

It is in this sense,—regarding the work apart from its special purpose, and judging of it only as a contribution to advanced scientific literature,—that we may fairly say, with Sir John Herschel, that the work is one of which any geometer might be proud. There is, indeed, ample evidence of the disadvantage under which Mrs. Somerville laboured, in the want of thorough mathematical training; but so much the more wonderful is it that she should have completely mastered her subject. Every page indicates her appreciation of the methods employed by Laplace and Lagrange. Where she does not strictly follow the *Mécanique Céleste*, she evidences a clear recognition of the purposes to be subserved by adopting a different course. We would not be understood as commending all the departures thus made, on the contrary, there are cases where it appears to us that on the whole it would have been preferable to have followed the processes of the *Mécanique Céleste* more closely, while there are others where certain more modern processes might perhaps with advantage have been introduced. But even in such instances we recognise in the course pursued by Mrs. Somerville the decision of one perfectly familiar with the subject in hand. And many of the changes must undoubtedly be regarded either as improvements, or else as altogether desirable when the scale of Mrs. Somerville's treatise is taken into account. Amongst instances of the former kind must be classed the method employed in the investigation of the equations of continuity of a fluid; amongst instances of the latter, we would specially cite the treatment of the theory of elliptic motion, in the opening chapters of the second book.

If, however, we were asked to point out the feature of this work which in our opinion most strikingly indicated the powers of Mrs. Somerville's mind, we should unhesitatingly select the preliminary dissertation. In this we have an abstract of the Newtonian philosophy such as none but a master-mind could have produced. Apart from its scientific value—and it has great scientific value—it is a work of great literary merit. If it is not in plan and purpose altogether original, inasmuch as it must be regarded as to some degree an abstract of Laplace's *Système du Monde*, it is, nevertheless, as Herschel has well remarked, “an abstract so vivid and judicious as to have all the merit of originality, and such as could have been produced only by one accustomed to large and general views, as well as perfectly familiar with the particulars of the subject.”

Three years after the appearance of the *Mechanism of the Heavens*, Mrs. Somerville published the work by which she

is probably best known to general readers. The *Connexion of the Physical Sciences* was, we believe, written at the suggestion of Lord Brougham, as an expansion of the admirable introduction to the *Celestial Mechanism*. It is a work full of interest, not only to the student of advanced science, but to the general reader. In saying this we indicate its chief merit and its most marked defect. It is impossible to conceive that any reader, no matter how advanced or how limited his knowledge, could fail to find many most instructive pages in this work ; but it is equally impossible to conceive that any one reader could find the *whole* work, or even any considerable portion, instructive or useful. The fact was that Mrs. Somerville recognised, or, which is practically the same thing, wrote as if she recognised no distinction between the recondite and the simple. She makes no more attempt at explanation, when speaking of the perturbations of the planets or discussing the most profound problems of molecular physics, than when she is merely running over a series of statements respecting geographical or climatic relations. It would almost seem as though her mind was so constituted that the difficulties which ordinary minds experience in considering complex mathematical problems had no existence for her. A writer, to whom we owe one of the best obituary notices of Mrs. Somerville which hitherto has appeared, tells us that the sort of pressure Mrs. Somerville underwent from her publisher as the earlier editions of the *Connexion of the Physical Sciences* "convinced her of her own unfitness for popularising science. When there was already no time to lose in regard to her proof-sheets, she had hint upon hint from Mr. Murray that this and that and the other paragraph required to be made plainer to popular comprehension. She declared that she tried very hard to please Mr. Murray and others who made the same complaint, but that every departure from scientific terms and formulas appeared to her a departure from clearness and simplicity ; so that, by the time she had explained and described to the extent required, her statements seemed to her cumbrous and confused. In other words, this was not her proper work."

Respecting her two other works, we shall merely remark that the *Physical Geography* appeared in 1848, and the *Molecular and Microscopic Science* in 1869, when she had reached the advanced age of eighty-eight years.

We may be excused for regarding Mary Somerville's life, in these pages, with reference rather to her astronomical and mathematical researches than to her proficiency in other branches of science. In this aspect of her career it is difficult, great as was the reputation she deservedly obtained, not to contemplate with regret those circumstances, the effects of unfortunate prejudices, whereby she was prevented from applying the full powers of her mind to the advancement of science. It is certain that no department of mathematical research was beyond her powers, and that in any she could have done original work. In mere mental grasp

few men have probably surpassed her ; but the thorough training, the scholarly discipline, which can alone give to the mind the power of advancing beyond the point up to which it has followed the guidance of others, had unfortunately been denied to her. Accordingly, while her writings show her power, and her thorough mastery of the instruments of mathematical research, they are remarkable less for their actual value, though their value is great, than as indicating what, under happier auspices, she might have accomplished.

We have mentioned that Mrs. Somerville was twice married. By her first marriage she had one son, Mr. Woronzow Greig, since deceased. A few years after Captain Greig's death she married her cousin, Dr. Somerville, by which marriage she had three daughters, two of whom survive her. The latter years of her life (twenty-three years, we believe) were passed in Italy. It has been said by one who was well acquainted with the circumstances that "the long exile which occupied the latter portion of her life was a weary trial to her. She carried a thoroughly Scotch heart in her breast; and the true mountaineer's longing for her native country sickened many an hour of many a tedious year. She liked London life, too, and the equal intercourses which students like herself can there enjoy; whereas, in Italy, she was out of place. She seldom met any one with whom she could converse on the subjects which interested her most; and if she studied, it could be for no further end than her own gratification. It was felt by her friends to be a truly pathetic incident that, of all people in the world, Mrs. Somerville should be debarred the sight of the singular comet of 1843; and the circumstance was symbolical of the whole case of her exile. The only Italian observatory which afforded the necessary implements was in a Jesuit establishment, where no woman was allowed to pass the threshold. At the same hour her heart yearned towards her native Scotland, and her intellect hungered for the congenial intercourse of London; and she looked up at the sky with the mortifying knowledge of what was to be seen there but for the impediment which barred her access to the great telescope at hand. With all her gentleness of temper, and her lifelong habit of acquiescence, she suffered deeply, while many of her friends were indignant at the sacrifice."

We shall venture to quote, in conclusion, some remarks of Sir Henry Holland on features of Mrs. Somerville's character and life which have been hidden from general knowledge:—"She was a woman not of science only," he tells us, "but of refined and cultivated tastes. Her paintings and musical talents might well have won admiration, even had there been nothing else beyond them. Her classical attainments were considerable, derived, probably, from that early part of life when the gentle Mary Fairfax—gentle she must ever have been—was enriching her mind by quiet study in her Scotch home. . . . A few words more on the moral part of Mrs. Somerville's character; and

here, too, I speak from intimate knowledge. She was the gentlest and kindest of human beings—qualities well attested even by her features and conversation, but expressed still more in all the habits of her domestic and social life. Her modesty and humility were as remarkable as those talents which they concealed from common observation. . . . Scotland,” he justly adds, “is proud of having produced a Crichton. She may be proud, also, in having given birthplace to Mary Somerville.”

R. A. P.

NATHANIEL BEARDMORE was the second son of Joshua and Marianne Dorothea Beardmore, and was born at Nottingham on the 19th of March, 1816. His father, an independent gentleman, shortly afterwards removed to London and then to Chudleigh, in Devonshire. Here he was educated, and at the age of sixteen was sent to Plymouth to study with Mr. George Wightwick, architect, for six months, and was then articled to Mr. James Meadows Rendel, civil engineer, for five years. At this time he evinced much interest in the study of practical astronomy, and the construction of a Newtonian telescope became a great feat of ambition with him. A brother engineer who shared to some extent in the same pursuits remembers well the perseverance that he displayed, and in the matter of specula his was superlative. The metal, the moulds, the melting and mixing were of course essential, so also the grinding and polishing. Failures were numerous, and many a night were these operations carried on until morning hours with crucibles on a kitchen grate. The landlord of his lodgings being pressed into the service with a pair of bellows, the unflagging movement of which was absolutely necessary to obtain the melting point for the amateur, whose zeal became shared if not comprehended by the veteran of seventy years. Of course experience brought knowledge, and it was found that regulus of antimony was not absolutely essential to a reflecting surface. A telescope was, however, produced, though probably the experience got in the process was the only result of value. Soon after the expiration of his pupilage he entered into partnership with Mr. Rendel, but the connexion terminated in 1848. For the first few years of his professional life Mr. Beardmore resided principally at Plymouth. In 1843 he removed to London, and in 1856 took a private residence at Broxbourne, in Hertfordshire, retaining offices in London. In the earlier part of his career he was engaged in various questions connected with engineering, but of late years he confined his attention almost entirely to the practice of hydraulic engineering, and had attained the position of one of the first hydraulic engineers of the day. Under his direction the *régime* of the River Lea was entirely remodelled; and at the time of his death he was engineer to the Public Works Loan Commissioners, the River Thames Conservancy Board, the Essex Sewers Commissioners, besides being consulted in all the more important questions of drainage

and water supply. In the year 1862 he brought out a "Manual of Hydrology," an extension of a smaller treatise called "Hydraulic Tables," published in 1850. This speedily attained 1 wide circulation, and is, in fact, the standard handbook of all engaged in practical hydraulic engineering.

Mr. Beardmore was a member of the Council of the Institution of Civil Engineers, and a member of the Smeatonian Club. He was elected a Fellow of the Royal Astronomical Society on January 8, 1858, and at one time frequently attended the meetings. He was also a Fellow of the Geological, Geographical, and Meteorological Societies, and of the last Society he was President in the years 1861 and 1862.

Mr. Beardmore was a man of rare uprightness and genuine goodness. His ready humour and originality rendered him popular wherever he went, and his courteous hospitality will long be remembered. In private life he was a man of most simple habits, disclaiming all ceremony, of a reserved and retiring nature amounting almost to shyness, but ever ready with kind advice given both professionally and privately in a generous spirit which pervaded every action throughout a life of usefulness. His health had been failing for two years, when he was seized with congestion of the lungs, the result of a cold, and he died on the 24th of August, 1872.

Mr. Beardmore married in 1841, Mary, eldest daughter of Mr. J. F. Bernard, of H.M. Civil Service, and had ten children, of whom eight survive.

BENJAMIN GODFREY, M.D., F.R.C.S., was born at Romsey, Hampshire, in November 1829. Having served his time as articled pupil to a firm of surgeons in his native town, he proceeded to London, and entered at Guy's Hospital, where he passed through the usual curriculum, and in 1852 obtained his diploma. In the same year he graduated M.D. in the University of St. Andrews. Having married, he settled at Enfield, where for twenty years he carried on a practice which, small at first, steadily increased until it became one of the largest for miles round. He was eminently fitted for his profession, both by natural qualities and acquired skill. Amidst unceasing calls upon his time he found opportunities for continuing his studies and acquainting himself more especially with the most recent and valuable additions to the literature of medicine. His patients, therefore, enjoyed the benefit of every new method, proved to be successful, of combating disease and alleviating pain.

Dr. Godfrey was elected a Fellow of this Society on February 12, 1858, and was also a member of various other learned societies, but he was able to attend but few of their meetings. He was an occasional contributor to the scientific journals, as well as the author of two small medical works on Vaccination and on Diseases of the Hair.

After a very brief illness, Dr. Godfrey succumbed to the heart

disease against which he had bravely struggled, and on the morning of November 22, 1872, he died at the early age of forty-three. For his sunny disposition and truly Christian character he was loved and trusted by a large circle of friends. More than two thousand persons of all classes assembled in the Enfield cemetery to witness the last sad ceremony, and thus to testify their affection and respect for the departed. Enfield will not soon forget Dr. Godfrey. A public subscription has been started, with the view of erecting a handsome monument to his memory.

RICHARD HODGSON, who died at Hawkwood, Chingford, Essex, on the 4th of May, after a very long illness, in a great measure induced by his untiring exertions in the cause of the Debenture-holders of the London, Chatham, and Dover Railway, was born in Wimpole Street in 1804. He was educated at Lewes, passed some time in a banking house in Lombard Street, and eventually became leading partner in the firm of Hodgson and Graves, the publishers in Pall Mall, from which he withdrew in 1841, and thenceforth gave up his time to scientific pursuits. First taking up Daguerreotype (then in its infancy), he introduced many improvements in the manipulation of the process, was very successful as an amateur in portraiture, and in obtaining magnified representations of microscopical objects, which have rarely been surpassed. He also spent some time in endeavouring to print from the silver Daguerreotype plate, by submitting it to chemical treatment, and proceeding, as is usual in copper-plate printing. Though he had some fair results, the process was too delicate and uncertain for general use, and he abandoned it to devote himself more exclusively to the microscope and telescope. In 1852 he built an observatory at Claybury, in Essex, in which a 6-inch refractor was mounted equatorially. This was afterwards removed to Hawkwood, and a transit-room added, which now contains the 4-inch instrument formerly in the possession of Dr. Lee, of Hartwell.

In 1854 he designed the diagonal eye-piece for observing the whole of the Sun's disc without contraction of the aperture of the object-glass, a description of which appeared in the *Monthly Notices* for December of that year.

For many years he was a constant observer of the Sun, and made a series of drawings of many solar spots. Whilst so engaged, at 11.20 A.M. on the 1st of September, 1859, he was fortunate in witnessing the remarkable outbreak in a large spot which was simultaneously observed by Mr. Carrington at Redhill. He was elected a Fellow of this Society on the 14th of April, 1848, a member of Council on the 12th of February, 1858, and he filled the office of Honorary Secretary from 1863 to 1867. He was also a Fellow of the Royal Microscopical and Meteorological Societies.

Professor ADAM SEDGWICK was born at Dent, Yorkshire, on

the 22nd of March, 1785. He entered Trinity College, Cambridge, in 1804, and graduated as Fifth Wrangler in 1808, the late Lord Langdale and Dr. Blomfield, Bishop of London, being his contemporaries ; the former as Senior, and the latter as Third Wrangler. In 1810, he was elected to a Fellowship of his College, which he retained to the time of his death. Mr. Sedgwick at once took an active part in the direction both of his College and University, and he filled at one time the office of Vice-Master of Trinity. He was during one year Proctor of the University ; and in this usually unpopular office, though he conducted it with great strictness in all essential points, he adapted himself so well to the feelings of the University students that he was exceedingly popular. His natural fondness for the study of geology, which in those days was scarcely known in England as a science, obtained for him, in 1818, the Woodwardian Professorship of Geology in the University, which had been held since 1788 by Professor Hailstone. It has been remarked by Professor Phillips that "his attention to geology was speedily awakened, and became by degrees a ruling motive for the long excursions, mostly on horseback, which the state of his health rendered necessary in the vacations. It was not, however, so much his actual acquirements in geology as the rare energy of his mind, and the habit of large thought and expanding views on natural phenomena, that marked him out as the fittest man in Cambridge to occupy the Woodwardian chair vacated by Hailstone. Special knowledge of rocks and fossils was not so much required as a well-trained and courageous intellect, equal to encounter theoretical difficulties and theological obstacles which then impeded the advance of geology." For the long period of nearly fifty-three years he remained the honoured occupant of this Chair, relieved only during the last two years of his life when his physical infirmities no longer enabled him to give his usual lectures, by Professor Morris, who in 1871 was appointed his deputy.

Professor Sedgwick's contributions to geology were numerous. They were mostly communicated to the Geological Society, the Cambridge Philosophical Society, or to the British Association. In the Catalogue of Scientific Papers, published by the Royal Society, thirty-nine memoirs are placed separately to his name ; fourteen in conjunction with Sir Roderick Murchison, and two with Mr. W. Peile. His first acknowledged publication was read before the Cambridge Philosophical Society in 1820, on the physical structure of the Devonshire and Cornish formations, and it contained the record of his observations made in the preceding year. He was much interested in researches connected with the geological formation of the south-western district of England ; and as early as 1819 he saw clearly that the Plymouth fossil corals were not to be identified with those of the mountain limestone, but that they were of an earlier epoch. Fifteen years afterwards, Professor Sedgwick found a co-worker in Sir R. Murchison, in conjunction with whom he was again occupied in

researches connected with the geology of Devonshire. At the meeting of the British Association held at Bristol in 1836, a joint paper was read on the carbonaceous strata between Dartmoor and the north-western coast of Devon, in which was pointed out for the first time the true geological position of the several deposits. In a subsequent memoir published in the *Transactions of the Geological Society*, these two great geologists gave a complete account of the district, and they not only attempted to describe the successive formations north of Dartmoor, but also to bring them into comparison with the formations which expand from the southern side of the Dartmoor granite to Start Point, and to the other headlands of the south coast of Devon. In 1838, the country north of Dartmoor was again surveyed by Professor Sedgwick, and in the following year he was engaged with Sir R. Murchison in adopting the final classification of the older sedimentary rocks of our two south-western counties.

Perhaps one of Professor Sedgwick's greatest works was his examination of the geological formation of North Wales, which was however the subject of an unfortunate controversy with his colleague Murchison. It appears that while Murchison was actively working out the succession of the strata in Shropshire and the adjacent part of Wales, Sedgwick was examining the country from Snowdon to the Berwyn Hills, and establishing the true succession of the strata to which he gave the name of Cambrian. Murchison, however, considered that the strata on which he had been working, and to which he had assigned the name of Silurian, was identical with that to which Sedgwick had given the name of Cambrian. On the authority of Murchison, Sedgwick at first accepted this arrangement, which was afterwards found to be erroneous. Though it was proved that Professor Sedgwick was correct in his original judgment, Murchison continued to assert for some time the correctness of his views, still claiming the upper Cambrian of Sedgwick as a portion of his own lower Silurian. Hence arose the controversy between these two distinguished men. Professor Sedgwick, however, on his part was only anxious to clear his scientific reputation from any slur arising from an error for which he was not responsible. Now that the two great geologists have been removed from us, it is but justice to the memory of Professor Sedgwick to allude to a subject which was the cause of much bitterness of feeling at the time, and to remark that his original opinions have been fully confirmed by subsequent examinations.

In 1851, the Council of the Geological Society awarded to Professor Sedgwick the Wollaston Palladium Medal "for his original researches in developing the geological structure of the British Isles, of the Alps, and of the Rhenish Provinces." Sir Charles Lyell, in presenting the medal, observed that "it was impossible within the brief limits of a single speech to enumerate all the Professor's various labours; but he referred especially to his memoirs on the magnesium limestone of the north of England,

on the trap-rocks of Durham and Cumberland, on the fossiliferous strata of the north of Scotland and of the Isle of Arran, on the mountains of Cumberland, of the adjacent lake district, and of North Wales, his essays on slaty cleavage, on the true age of the strata of Devon and Cornwall, and on the Alps, and the Rhenish Provinces, as worthy of all praise and valuable contributions to the treasures of British science."

It is not required, in this very brief sketch of the labours of Professor Sedgwick, to enter into any detail of the various geological researches which occupied his attention during his long career; but we may truly remark, that no member of the University ever laboured to a greater degree than he did to elevate the character of Cambridge as a school for the natural sciences. The time, money, and talent which he expended on the formation of the Woodwardian Geological Museum can only be duly appreciated by a careful examination of the choice collections which are not only noted for their excellence and rarity, but also for the perfect and systematic manner with which the specimens are arranged. To this storehouse of science he has himself contributed many thousands of rock specimens, chiefly British, besides a valuable series of organic remains.

In April, 1871, Professor Sedgwick resigned the active duties of his Chair, which he had so worthily filled for more than half a century, his increasing years and infirmities preventing that attention to his ordinary lectures, which he to the last was anxious to give. He, however, felt always interested in the scientific inquiries which were carried on around him, and he also derived much pleasure in occasionally corresponding with his friends of former years. He was popular as a lecturer, for his style was energetic, philosophical, and clear; and notwithstanding his great age, he was as remarkable for his humour and anecdote as when in middle age. It has been truly written of him that, "For high moral courage, for honesty and singleness of purpose, for generosity of nature, and for a hatred for all that is mean and base, no name ever stood higher than that of Adam Sedgwick. Indeed, he was beloved by all who had the privilege of his friendship. In his declining years he had the satisfaction of feeling and knowing that he had not lived in vain, and that, besides lending a helping hand towards the elucidation and popularisation of geology as a science, he had been, during half a century of hard labour at Cambridge, the teacher and trainer of many first-rate practical geologists, several of whom had done their appointed tasks, and had passed away before him, to whom they looked up as their master."

Professor Sedgwick became a Fellow of this Society in 1830, but he has never contributed either to the *Memoirs* or *Monthly Notices*. He was, however, none the less interested in astronomy, especially in former years, as those who have been intimately acquainted with him have frequently testified. He was one of the oldest surviving Fellows of the Royal Society, having

been elected in 1821. He was also a Fellow of the Geological Society, and, having served on the Council, was elected to the Presidential Chair in the years 1829-30-31. Professor Sedgwick was in holy orders, and was Canon of Norwich, which preferment he has held since 1834.

The Professor had been ailing for some time, and for many weeks preceding his decease he had been in a precarious condition, no hopes being entertained of his recovery. During the last few days of his life his weakness increased; and on the morning of January 27, 1873, in the eighty-eighth year of his age, he quietly passed away, regretted by not only the members of his college, with whom he had so long dwelt, but by the scientific world generally.

When the intelligence reached England that our esteemed and respected Associate, M. DELAUNAY, had lost his life by the upsetting of a pleasure-boat near Cherbourg, a deep and general regret was felt by his co-workers in astronomy, and especially by the Fellows of this Society, who had little more than two years previously so cordially welcomed his presence among them. Shocked at the time, as we all were, by the suddenness of the calamity which had deprived us of the services of so distinguished an astronomer, we can scarcely even yet realise the extent to which our science has been the loser by his melancholy and premature death.

Charles Eugène Delaunay was born at Lusigny, in the Department of the Aube, in the year 1816. Of his early life little is recorded, till at the usual period he entered the Ecole Polytechnique at Paris, where he soon became one of the foremost pupils in the school. Being at the head of his class in 1836, he passed in that year into the Ecole des Mines. While here his vacation reports and journals on the coal-seams in the valley of St. Etienne and Creusot, as well as those on the principal iron and steel works of France, gave a remarkable evidence of that clearness of thought and skill in theoretical speculations, which have been so marked in all his subsequent investigations. While he was still a pupil at the Ecole des Mines, his former masters, having full confidence in the originality and power of his mathematical knowledge, proposed his appointment as teacher of geodesy at the Ecole Polytechnique. Though Delaunay was willing to accept the offer, certain objections were made by the managers in consequence of the anomaly of a pupil of one school holding a tutorial position in the other. The council of the school, at the head of which was M. Cordier, appreciating the great talents of young Delaunay, obtained, however, a special sanction for him to accept the office. He thus obtained the position of a teacher, and afterwards of a professor, in the school from which he had only lately passed with so much honour. At a subsequent period he was also appointed a professor in the Ecole des Mines.

It was part of the curriculum of the Ecole des Mines to give

a preparatory course of instruction for the benefit of engineers, both for those attached to the Corps des Mines and those connected with the mining industry of France, and thus a void was filled up in the subjects taught which were not included in the course of study at the Ecole Polytechnique. From 1845 to 1850 Delaunay was one of the most successful of the professors in this section, having classes for the teaching of descriptive geometry, stereotomy, machine drawing, analytical mechanics, and elementary physics. His manner of imparting knowledge was so clear and so well appreciated by the pupils, that these classes became the most popular division of the school. In 1850 Delaunay attached himself exclusively to the Ecole des Mines, and, like his predecessors, Lamé, Regnault, and Sénarmont, was appointed to successive grades in the Corps des Mines, becoming engineer-in-chief in 1858. In 1867 he was raised to the first class of his rank.

In 1841, M. Delaunay published his first memoir entitled, *Sur la distinction des Maxima et des Minima dans les questions qui dépendent de la Méthode des Variations*. This was followed by other important works on various subjects, such as on the theory and precession of the equinoxes; theory of the tides; theory of the motion of the Moon; elementary treatises on astronomy and mechanics; and a large number of miscellaneous papers in the *Comptes Rendus*, in the *Connaissance des Temps*, and in the *Journal de l'Ecole Polytechnique*. His first memoirs exhibited great mathematical power, and foreshadowed the scientific rank which he soon attained among geometers. Fortunately his attention was drawn to astronomical questions, in the discussion of which he became so completely engaged that his whole leisure time was devoted to this object. His treatise on the theory of the tides was an important work, and it was about this period that the question of the lunar theory first began to occupy his mind. His elementary books on astronomy and mechanics are excellent textbooks for schools, in which he showed the rare talent how to popularise science without lowering it.

Delaunay's great work on the Lunar Theory is, however, that which has made his name so universally known among us, and for which this Society had the honour of electing him one of its Associates in 1862. Few of us, however, can properly estimate the magnitude of this voluntary labour of Delaunay. Most of us know to what extent an exact acquaintance of the motion of the Moon affects questions in astronomy and navigation; and we also know that there are very great difficulties presented in the process of determining the values of the co-efficients of the numerous lunar inequalities. If we were to express the motion of the Moon by analytical formulæ, in which no sensible term is neglected, from which tables could be formed in which all empiricism was to be excluded, we should then have some faint notion of the immense work which Delaunay had undertaken to investigate. The necessity of carrying the approximation farther than had been previously done, increased the labour to an enormous extent.

It will be unnecessary in this very brief sketch to enter into the peculiarities of Delaunay's great work on the Lunar Theory. It was only in February, 1870, that Professor Adams presented to him, in the name of the President, the Gold Medal of this Society, as an acknowledgment of the high appreciation which is entertained for his work in this country. On that occasion, Professor Adams gave, with great minuteness, his testimony to the great value and importance of Delaunay's researches on the Lunar Theory, entering at the same time into a complete history of the subject, and pointing out in what Delaunay differed from those who had already published treatises on the theory. To this valuable address of Professor Adams, which is given *in extenso* in Vol. XXX., No. 4, of the *Monthly Notices*, anyone who wishes to acquaint himself with the details of the process adopted by Delaunay in his research is referred.

From the year 1846, M. Delaunay devoted all his available time to the carrying out of this important work. After fourteen years of assiduous labour, he published in 1860, the first volume, entitled *La Théorie de la Lune*, forming one of the volumes of the Memoirs of the French Institute. During this interval, he, in separate memoirs, published papers on several questions relating to the theory, notably that on the secular acceleration of the mean motion of the Moon, which at this time was a subject exciting much controversy. The magnitude even of this supplementary work may be conceived from an extract from an interesting review of the state of this controversy in 1859, by the Rev. R. Main, then President of the Society. "The reader, who desires to see the exact expression for the acceleration arrived at by M. Delaunay, must consult the work referred to, as it is too long for insertion here, consisting, as it does, of *forty-two* terms. Thus much may be said of it, that it takes in every possible term as far as the eighth order, including those terms depending on the inclination and excentricity of the lunar orbit; and that all the terms calculated by Mr. Adams are in exact accordance with it." In 1867, the second volume appeared in continuation of the first, completing by far the most difficult portion of the work. The third volume, of which the contents have, for the greater part, been prepared for some time, will bring this great undertaking to a conclusion so far as concerns the theory.

"This enormous labour, which has occupied M. Delaunay for nearly twenty years, has been performed by him without assistance from anyone. Indeed, from the nature of the calculations which are required, it would not have been easy to obtain any effective assistance. In order to ensure accuracy, M. Delaunay has omitted no means of verification, and he has performed all the calculations, without exception, at two separate times, with a sufficient interval between them to prevent any special risk of committing the same error twice in succession.

"The volumes before us are perfect models of orderly arrangement. Notwithstanding the great length and compli-

cation of the calculations, the whole work is so disposed that any part of it may be speedily examined with the utmost readiness by anyone who may wish to test its accuracy.

“ Finally, the analytical expressions which have been obtained for the Moon’s co-ordinates are converted into numbers, by substituting for the elements the most accurate numerical values which the comparison of theory with observation has made known. * * * The work is complete in itself; in it the very difficult and complicated problem of determining the Moon’s motion is attacked by a perfectly original method, and that one as powerful and beautiful as it is new. The work has been planned with admirable skill, and has been carried out with matchless perseverance. The result is an enduring scientific monument of which our age may well be proud.” *

M. Delaunay considered truly that the plan which he had laid down for himself, would remain incomplete, until the analytical expressions of the theory were reduced into the practical form of tables. The preparation of lunar tables representing his theory has therefore been going on under his direction. The numerical calculations have been made for a considerable portion, those for the longitude being finished and in the printer’s hands, while the remaining portion is far advanced. The Bureau des Longitudes took this part of the work under its patronage, and obtained the necessary funds from the Government, so that in a few years hence we might have expected its completion, for it was hoped that the new duties imposed upon Delaunay at the Observatory would not materially impede the progress of the calculations. But all is now in doubt. The master-mind has been suddenly taken from this labour of love, and it is not yet certain whether the calculations are far enough advanced to be intrusted to other hands. May we indeed have some hope that they are left in such a condition that others can interpret them, and thus preserve our science from an irreparable loss. In any case we can adopt with sincerity the words of M. Puiseux, Member of the Bureau des Longitudes :—“ Quoique l’auteur ne soit plus là pour y mettre la dernière main, il ne sera sans doute pas impossible de terminer ce monument scientifique. Espérons pour la gloire de l’astronomie française, que ce service sera rendu à la science, que ce suprême hommage ne manquera pas à notre illustre confrère.”

In 1870, M. Delaunay was appointed Director of the Observatory of Paris, in succession to our distinguished Associate, M. Le Verrier. Installed in his new office, Delaunay was soon convinced of the importance of the numerous improvements made in the condition of the Observatory since the death of Arago; and many times he has been heard to express his adhesion to the various innovations introduced by his predecessor. He had not, however,

* Address of Professor Adams on presenting the Gold Medal of this Society to M. Delaunay. *Monthly Notices*, vol. xxx. pp. 131, 132.

long been resident at the Observatory when the terrible war broke out between France and Germany, which was intensified by the disasters consequent on the prolonged siege of Paris. His whole time and thoughts were now concentrated on the best means to be adopted for the preservation of the Observatory from the effects of the bombardment. All his delicate instruments were dismantled and stowed away in sheltered places, and all observations were suspended. Even all this foresight and care nearly failed, for, during the last days of the Commune, their troops took possession of the building and grounds, which they turned into a military station. Although a few small instruments were destroyed, no very serious damage was done; but in the last moments of their power the soldiers threatened to set fire to the Observatory, making preparations to do so, when the rapid approach of the Versailles troops happily saved the building and its valuable contents from destruction. After the conclusion of peace the Observatory was soon restored to its former condition, and the usual observations were resumed.

Although France can boast of having had among its mathematicians some of the greatest of astronomers, yet there has been a complete absence in that country of those numerous public and private observatories which are to be found in England and Germany, and even in Italy. No one was more sensible of this deficiency of means for the practical advancement of astronomy in France than Delaunay. Seeing thus the importance of an increased number of observatories in France, he, in conjunction with M. Le Verrier, made an application to the Government for the pecuniary assistance which would be needed to establish a certain number of astronomical and geodetical stations in different parts of the country. These observatories were intended to be established according to a joint plan arranged by M. Delaunay and the Bureau des Longitudes. We owe, also, to Delaunay the independence of the Observatory of Marseilles, which had formerly only been a branch of the Observatory of Paris, the foundation of an Observatory at Toulouse, and the project for an Observatory at Besançon.

When, in 1854, the administration of the Observatory of Paris was separated from that of the Bureau des Longitudes, several of the members of its staff, who were naturally "of the school of Arago," retired to a common residence in the Rue Nôtre Dame des Champs, where they established a small observatory. Delaunay, whose sympathies and habits were akin to those of Mathieu and Laugier, occupied an apartment in the same house. Hence arose that undivided friendship which lasted through life. It was here where he carried on most of his researches; he seldom went out, except to give his accustomed lessons at the Ecole des Mines or the Sorbonne. At five in the morning he was often at his work, never finally quitting it till late in the evening. It was while passing his life in this peaceable, and, to him, happy manner, that he was called by the late Emperor to

the control of the Observatory of Paris. He considered it to be his duty to accept the charge, but it was at a sacrifice of some peace of mind that he did so. In the early part of his directorship he often looked with sorrow on his late modest apartment, to the many hours consecrated to his researches, either within its walls or at his small country residence in Champagne. Delaunay soon, however, saw that he had now a public duty to perform. He perceived that the rapid advancement of astronomy required corresponding efforts, on the part of a great national establishment like that under his direction, to meet the demand for observations suitable to the present state of the science. Had his life been spared, he would no doubt have succeeded in making the Observatory the great centre of astronomy in France. Shortly before his death he remarked: "We are going to do many things; the Observatory intends to devote all its energies to the re-observation of Lalande's Catalogue; to continue the ecliptic star-charts commenced by Chacornac; to observations of double stars; and finally we are making preparations for new determinations of the longitude of Brest, Greenwich, and Neuchâtel." The observation of the minor planets during the second half of the lunation, according to the original convention agreed upon by the Astronomer Royal and M. Le Verrier, has been continued by M. Delaunay with great success, excepting only during the siege.

M. Delaunay had the misfortune to lose his wife a few years after their marriage, leaving an only son, Gaston Delaunay, now principal guardian of the forests of Vitry le François. His aged mother has survived him, and his devotion to her was well known. The moment when it was possible for him to leave Paris after the siege, his first thought was of his poor old mother, of whom he had heard no tidings since the investment of Paris by the Germans. He hastened to Ramerupt, and in person related all his cares and anxieties, and then returned to his duties of reconstruction with a lightened heart.

Delaunay was a member of several of the learned societies; he also had received the honorary degree of Doctor in Science. He was a member of the Academy of Sciences of Paris, the chair of which he had only lately filled. He was a foreign member of the Royal Society, and, as we have already remarked, an Associate of the Royal Astronomical Society.

The circumstances of Delaunay's death will ever remain a sad episode in the history of astronomy. In his full mental power, but needing some temporary recreation, he left the meeting of the Bureau des Longitudes on Tuesday, July 30, 1872, for the purpose of spending a few days on the coasts of Normandy, in company with his cousin, M. Millot, Controller of the Post. On Sunday, August 4, he wrote from Bayeux that his health was excellent, that he intended passing one or two days at Cherbourg, and return to Paris on Thursday following. On Tuesday morning a telegram was received in Paris in these words:—"Hier, à

Cherbourg, un canot monté par quatre personnes a chaviré dans la rade. Les quatre personnes ont péri; l'une d'elles est M. Delaunay, Directeur de l'Observatoire de Paris. Son corps a été retrouvé à l'île Pelée, à cinq kilomètres de Cherbourg." Thus, with his cousin and two boatmen, our distinguished and lamented Associate suddenly met his death at the age of fifty-six, amid the regrets of the whole scientific world, and in the full powers of that gifted intellect which had been so long devoted to the successful development of some of the most important branches of mathematical astronomy.

It is a singular fact that the family of M. Delaunay have, on former occasions, been called to mourn the loss of relations by drowning. Delaunay himself had a natural dread of the sea, and indeed of ships and boats of all kinds. Having this great aversion for boating, he must have been enjoying a great buoyancy of health and spirits at Cherbourg to have accompanied M. Millot on this fatal excursion. His friends cannot understand how he could have been prevailed upon to form one of the party, as the loss of his father and brother was ever present in his mind on an occasion of this kind. His father perished in the presence of his wife and son while bathing in an open river near Troyes; while his brother shared a similar fate some years afterwards, also while bathing, very nearly at the same spot as his father. E. D.

PROFESSOR FREDERIK KAISER was born at Amsterdam on the 10th June, 1808, of German parents, whom the events of the Continental war had led to take up their residence in Holland. At the early age of seven years he had the misfortune to lose his father, but this loss was to a great extent repaired by the kind care of his uncle, J. F. Kaiser (who spelt his name Keyser, erroneously in the opinion of his nephew). This gentleman, who had left his native place, Nassau-Dietz, early in life, and settled at Amsterdam, was a great lover of astronomy, and made many observations which were published in the *Connaissance des Temps*, Bode's *Jahrbücher*, and other places; and also took a principal part in a determination made in the year 1806 of the difference of longitude between Amsterdam and Utrecht by gunpowder-signals. Having no children, he adopted his eldest nephew, the subject of our notice, who was one of a family of eight, and encouraged his youthful taste for science, superintending his education with truly paternal solicitude until his own death in 1823. Three years after this, while still but eighteen years of age, young Kaiser was appointed observer at the Leyden Observatory, at the recommendation of his uncle's friend, Prof. Moll.

The University of Leyden had possessed a small observatory from the year 1632, but that to which our late Associate was appointed dated from 1816-17, when the Government of the Netherlands, soon after its deliverance from the French yoke, felt it incumbent upon them to found a building for astronomical

observations, but unfortunately resolved upon a restoration of the University Observatory, although warned that it could never be but a makeshift. In the year 1822, the King, William I., presented this establishment with a large reflecting telescope, from the use of which great expectations were entertained. But it was in reality a very inferior instrument, the maker having acquired a reputation he by no means deserved, and no observations of any delicacy or advantage to modern science could be made with it. The vexation this caused to Prof. Ekama, who then occupied the chair of astronomy at Leyden, in all probability accelerated his death, which took place early in 1826. He was succeeded by Prof. Uylenbroek, under whom Kaiser entered upon his duties at the Observatory. He found everything in very bad condition, the instruments either old, broken, or utterly wanting in proper appliances for accurate observations. To make any such measurements or determinations was out of the question, and Kaiser was obliged to confine himself chiefly to occultations, and other casual phenomena. Uylenbroek's attention was absorbed in his professorial duties, virtually occupying the chair of 'Physics as well as of Astronomy, both which he taught with great diligence and success till 1837, when, on the death of his coadjutor, the Professor of Physics, he devoted himself entirely to that subject, and resigned the teaching of astronomy and the direction of the Observatory to Kaiser. From this time a new epoch in Dutch astronomy commenced. Kaiser's treatise on Halley's comet had already attracted notice, and he had now influence enough to have some good instruments procured for the Observatory, whilst the papers which he published from time to time kept up an increasing interest in astronomy amongst his countrymen. Thus he had the satisfaction of obtaining in 1856 provision in the Budget for the building and equipment of an entirely new observatory. This was completed in 1860, and furnished with instruments in 1861, notably with a meridian circle by Pistor and Martins, and two parallactically-mounted refractors by Merz (one of these being provided with an Airy's double-image micrometer by Simms). In 1866 Kaiser was further empowered to publish the *Observatory Annals*, the first of which appeared in 1868. It is unnecessary to dwell here upon the valuable contribution formed by these volumes to the progress of astronomy; they have obtained, as is well known, for the present establishment at Leyden, a very high rank amongst the observatories of the world, which we trust it will long continue to maintain. Unfortunately not long after astronomy in Holland had thus been placed upon a stable foundation, and a noble beginning of regular observing work commenced, the strength of Prof. Kaiser began to fail. In the spring of every succeeding year he suffered with a painful disease in the chest, and was compelled to desist temporarily from night exposure. In November 1871, at a time when he thought his health had considerably improved, he was occupying himself with some measures of

planetary diameters, when he was seized with a sudden hæmorrhage; and this time he did not rally from the attack, as he had done on previous occasions. Through the winter and spring he was gradually sinking, and this was accelerated by a severe loss which he sustained on the 25th of May, and which affected his spirits very seriously—the death of his wife, with whom he had lived in uninterrupted harmony for a period of forty-one years. At last he quietly passed from this life on the 28th of July last, having just entered his seventy-fifth year. His mother had died at a very advanced age two years previously. He left one daughter and three sons; the well known Dr. P. Kaiser being one of the latter.

W. T. L.

PAUL AUGUSTE ERNEST LAUGIER was born at Paris on the 22nd of December, 1812. He was the son of André Laugier, a distinguished chemist in the beginning of the century. He became a pupil in the Ecole Polytechnique, from whence in 1834, in the second year of his studies, he was appointed to the Observatory of Paris as a pupil astronomer, an office which had just been created at the instance of M. Arago. Under the direction of this distinguished astronomer, and assisted by the friendly counsel of MM. Bouvard and Mathieu, he soon became a skilful observer, and one of the most active assistants at the Observatory. Although employed in the frequently harassing daily routine of the ordinary observing work, he found time and zeal enough to undertake a special series of observations of the solar surface. In 1841 he presented to the Academy of Sciences a Paper, "On the Movements of the Solar Spots," a brief abstract of which appeared in the *Comptes Rendus* for 1843. In this memoir, Laugier gave as the result of his research, that the solar spots had a peculiar motion of their own, independently of that produced by the motion of the photosphere in the neighbourhood of the spot, and that the time of rotation of the Sun on its axis determined from the observation of several spots is not, from this cause, always accordant. Although convinced himself of the reality of his solar results, Laugier at this time was one of those modest men who have too little confidence in their powers, to venture laying any deduction that is novel before the criticising eyes of their fellow-workers; hence this memoir was never published in its entirety. It has been remarked by M. Faye, that "others have followed in his track; a new branch of science has taken birth on the ground which he had broken, and which is being rapidly developed. It is not, however, the less true that we owe the first germs of it to the unfinished memoir of Laugier, and it is at this moment a melancholy satisfaction for me to have waited until now, before making it public."

The numerous duties which necessarily fall upon a young and active observer at a large Observatory, would have been a sufficient excuse for devoting his leisure hours to other and less scientific occupations. His love for astronomy, however, would not

allow him to do this. He made himself acquainted with the method of calculating elements and ephemerides of comets. He was also the discoverer of a telescopic comet in the constellation *Draco* on the 8th of October, 1842. In a few days after the discovery he published the elements of its orbit. For this joint work, as discoverer and calculator, the Academy awarded him the Lalande Astronomical Prize in 1843. Besides devoting much attention to the observation of this comet, Laugier presented several important papers to the Academy, notices of which are inserted in the *Comptes Rendus*. Among these are the following, "On the orbit of Halley's Comet at its appearance in 1835;" "On the Comet discovered at Marseilles by M. Gambart," and "On the ancient appearances of Halley's Comet, especially that observed by the Chinese Astronomers in 1378."

M. Laugier left the Paris Observatory in the beginning of 1854, in company with others who were connected with the family of M. Arago, the late Director. The loss of the use of the instruments at the Observatory was felt by him exceedingly, principally because many subjects on which he was engaged were still unfinished, and the fear that arose in his mind that he might never have the means of bringing them to a successful conclusion. Laugier soon found, however, that his fears were groundless. He found ample time and material for continuing his researches at his residence in the Rue Nôtre Dame des Champs. The writer of this notice saw him here in the summer of 1854 occupied on the reduction of the observations which formed the material for his important memoir, "*Sur la détermination des Distances Polaires des Etoiles Fondamentales.*" A remark made by him at this time deserves to be recorded as a striking illustration of the great respect he entertained for the long and continuous series of fundamental observations made at Greenwich. On a passing allusion being made to the *Greenwich Observations*, several volumes of which were near him, he exclaimed, with considerable animation, "No books in my library are so precious to me as these records of the skill, order, and continuous labour of my *confrères* at Greenwich." The important memoir on the N.P.D. of fundamental stars was published in 1857, and forms a part of Vol. XXVII. of the *Mémoires de l'Académie des Sciences*. The observations were made at the Paris Observatory with the mural circle of Gambey, in the interval between the end of 1851 and the date of M. Laugier quitting the Observatory, owing to the changes in the *personnel* which took place on the appointment of M. Le Verrier as Director. At this time, however, the observations were nearly completed. The memoir is divided into two sections. In the first, he gives a description of the mural circle of Gambey, and a detailed account of the processes used in the reduction of the observations; while in the second he discusses the N.P.D. of 140 stars published in the principal star catalogues, by combining the different results into a normal catalogue, with which he compared the separate N.P.D. given in

each, including the results of his own determination. The comparison shows that the mean error of M. Laugier's N.P.D. for all the stars is only $\pm 0''.447$, a sure proof of the general excellence of his observations.

In the *Comptes Rendus* for 1853, are papers by M. Laugier on a new and very accurate determination of the latitude of the Observatory of Paris from the meridional observation of circumpolar stars, and a catalogue of nebulae observed during the years 1848 and 1849. On many occasions, Laugier afforded considerable assistance to Arago in his physical researches, including those on photometry and magnetism. In 1847, he investigated the proper motion of three stellar clusters formerly observed by Messier. He was also the author of an excellent treatise on a portable meridian-circle to be used for the determination of geographical positions. This work was published under the authority of the *Dépôt Général de la Marine*.

In June, 1843, Laugier was appointed an assistant-member of the Bureau des Longitudes, in the room of Savary, and he became a titular member in 1862. After the death of Arago in October, 1853, and the consequent divided interest of the Bureau des Longitudes and the Observatory, the preparation of the *Connaissance des Temps* and the *Annuaire* became almost the only important duty left to the care of MM. Mathieu, Laugier, and other active members of the Board. Since 1861, Laugier undertook a very important part of the calculations of the *Connaissance des Temps*, especially those portions which could not well be intrusted to ordinary computers, such as the section containing eclipses of the Sun and Moon, the tides, and occultations of stars by the Moon. Through his suggestion also, the eclipse-maps, similar to those found to be so useful in the *Nautical Almanac*, were inserted. He was in the habit of making for many years observations of the magnetic inclination and declination for publication in the *Annuaire*.

M. Laugier was elected in 1843 a Member of the section of Astronomy in the French Academy of Sciences, and an Associate of the Royal Astronomical Society in 1848. For some years preceding his death, he held the office of Examiner at the Naval School at Brest, where he was ever anxious to encourage a taste for scientific pursuits. He always felt an infinite pleasure in recommending the young marine officers to the notice of the Bureau des Longitudes, whenever they showed any skill in nautical science.

M. Laugier married the daughter of M. Mathieu, and the niece of Arago. For some years his health had not been satisfactory, ever since, in fact, the death of his son, a youth of great promise. The premature loss of his brother in February 1872—a man also distinguished in science, and only lately chosen a Member of the Academy of Sciences in the section of Medicine—for whom, on account of their difference of age, he had almost a parental tenderness, had a great effect upon his spirits, and the

combined stroke evidently tended to shorten his days. His death took place at Paris on the 5th of April, 1872, in the sixtieth year of his age. He succumbed at last to a severe attack of gout of several days' duration. His loss was felt in the salons of science, which were thus deprived of the society of one whose whole life was a model of uprightness. His manner was calm and reserved, apparently approaching to coldness, but those who knew him best have spoken of his goodness of heart, and of the honesty of purpose which guided him in all the relations of life. No more appropriate conclusion to this brief sketch can be given than that contained in the following remarks by the lamented Delaunay, who, alas! was so soon to follow him,—“Laugier was truly a friend of mine. For the last eighteen years we have lived in the greatest intimacy. Living under the same roof, occupying ourselves on similar researches, we were always in each other's society. Our lives were bound up together, we were as one individual. It is from this daily intercourse with him that I have been able to appreciate all that was good and honest in his heart; all that was right-minded in his judgment. I naturally sought his counsel under all circumstances. Never have I found his advice in fault; never have I had cause to regret following it. Laugier will no longer exist among us, but he will never cease to live among my most cherished remembrances.” E. D.

Dr. FRIEDRICH MAGNUS SCHWERD was born at Osthofen, near Worms, on the 8th of March, 1792. His father was a clerk in a court of justice, and his amount of early education was not very great. As a boy he was very fond of wandering in the solitary woods and meadows; but also showed indications of extraordinary mechanical talent. When he was fifteen years old, his parents removed to Frankenthal, and here his regular education may be said to have commenced. A Catholic priest, named Heinrich, instructed him in French, Latin, Mathematics, and Logic; and his clear elucidation of the subjects he taught left a lasting impression on the mind of young Schwerd. Somewhat later he had the opportunity of studying the use of astronomical instruments under the Abbé Bary at Mannheim. After passing at Mayence the examination of the Ecole Normale of Paris, he was appointed on the 2nd of January, 1814, by the French Government to a vacant tutorship at the Ecole Secondaire at Speyer. When the Palatinate became part of the kingdom of Bavaria, its educational institutes were reorganised, and Schwerd was raised in October 1817 to the rank of Lyceal Professor (at the Gymnasium.) On the establishment of a Lyceum at Speyer, in 1836, he was made Professor of Mathematics and Physics there; an office which he continued to hold for the remainder of his life, though he resigned that at the Gymnasium in 1864.

The health of Professor Schwerd was first shaken in the year 1868, by a violent attack of inflammation of the lungs, from which however he recovered, and those who saw him afterwards actively

engaged in the labours of his office, believed that he had still many years to live. His death, however, took place three years afterwards; he passed away tranquilly and without suffering, on the 22nd of April, 1871, leaving six sons and two daughters to mourn his loss. His wife, with whom he had lived in happiness for many years, had preceded him so long ago as 1846.

To astronomers Schwerd is best known by his observations of circumpolar stars made in 1826, 1827, and 1828, at Speyer, a reduced catalogue of which was published by Oeltzen at Vienna, in 1856. The earlier numbers of the *Astronomische Nachrichten* also contain several observations made by him of occultations and comets, including Halley's Comet at its appearance in 1835. The small Observatory of the Lyceum, in which these observations were made, was built in 1823, and presented by King Maximilian Joseph with a 20-inch meridian-circle by Reichenbach and Ertel, which was first used in February, 1826. These, however, were by no means the whole of Schwerd's directly scientific labours. He made a valuable contribution to geodesy in the measurement of a base-line in the Palatinate, and comparing it by triangulation with the longer one measured under royal authority by Laemmle in 1819-20. He also distinguished himself in the field of optical inquiry, and in the year 1835 published a work on the "Analytical Development of the Phenomena of Diffraction derived from the Fundamental Principles of the Undulatory Theory of Light." It is only necessary to mention here one other of the many labours of Professor Schwerd,—the construction of a new kind of prism-photometer, about the same time that Sir John Herschel was using his astrometer at the Cape of Good Hope. With this instrument, which he contrived at Munich, Schwerd made many measures of the quantity of light given out by several of the brightest stars. He was elected an Associate of this Society in 1837.

W. T. L.

PROCEEDINGS OF OBSERVATORIES.

Royal Observatory, Greenwich.

The usual course of observations with the Altazimuth was interrupted in the latter part of the year by the dismounting of the instrument, in order that the pivots of its horizontal axis might be repaired. With the view of securing a better determination of the zero of azimuth, the practice was introduced in November 1871, of observing, when practicable, a low star instead of the collimator for combination with a high star; this soon revealed the existence of discordances in the zero of azimuth as determined from the high and the low objects, which could only arise from irregularity of the pivots of the horizontal axis. On examination these were found to be much cut, and the instrument was, in consequence, dismounted on 1872, September 20, so that the pivots might be re-turned, and new segmental bearings made

similar to those which have been so successful in the case of the Transit Circle. This proved a more troublesome operation than had been anticipated, and the instrument was not brought into use again till 1873, January 8. Whilst the pivots were being repaired the opportunity was taken of making several minor alterations, the chief being that the levels can now be conveniently read off from below by means of mirrors suitably placed above them; for this it was necessary to have the divisions etched on the glass. It is hoped that the improvement in the form of the bearings, combined with due attention to the lubrication of the pivots, will effectually preserve them from injury in future.

The system of star-observing with the Transit Circle has been considerably extended by the formation of an extensive working catalogue containing, in addition to stars for other purposes, all circumpolar stars down to the sixth magnitude, to be observed assiduously both above and below the Pole, as a check on the collimation error. No sensible change appears to have taken place in the discordance between the results of the Nadir observation and of Reflexion Stars; by the application of a correction to the former the determination of zenith-point is practically made to depend on the results of star observations alone.

The Normal Sidereal Clock has fully maintained its character for steadiness of rate throughout the year; the increase of daily losing rate due to the barometric inequality appears to be $0^s.31$ for 1 inch rise of the barometer, while accidental variations in the personal equation of the observers completely mask any other irregularity of the clock.

For the phenomena of *Jupiter's* satellites, of which an unusually large number have been observed, the Great Equatoreal has been almost exclusively used, and by its means estimations have, in several instances, been made of the phases of the eclipses. These observations will be found in the *Monthly Notices*.

The observations with the Water Telescope have been brought to a satisfactory conclusion, as will be seen from the subjoined results for the latitude of the instrument, which show by their close agreement that there is no sensible error in the co-efficient of aberration adopted in the *Nautical Almanac*.

		Spring.	Autumn.
1871	..	51° 28' 34".4	51° 28' 33".6
1872	..	51° 28' 33".6	51° 28' 33".8
Means		51° 28' 34".0	51° 28' 33".7

The volume for 1870 was distributed last summer, but the printing of the next volume is not so forward as usual, though all the MSS. for 1871 were in the printer's hands at an early period.

As it has been decided to include solar spectroscopy in the regular course of observations, a spectroscope to be attached to

the Great Equatoreal has been designed for this purpose, as well as for observations on stars and nebulae, and is now in course of construction. The valuable series of Sun pictures, taken with Mr. De La Rue's photoheliograph at Kew, is to be continued with the same instrument at Greenwich, and a building has been prepared in which it will be installed in the course of a few days. The continuity so necessary in such records will thus be preserved nearly unbroken.

Active preparations have been going on during the past year for observation of the approaching Transit of *Venus*. Nearly all the instruments are now ready, and suitable huts have been erected for them, twenty in all being required. Several of the intending observers have thus been enabled to acquire that dexterity in the use of the instruments which practice alone can give, whilst some trifling deficiencies in the original equipment, pointed out in this way, have been supplied. All the forms for computation have been printed, and their efficiency tested in actual work. The importance of these early preparations cannot be over-estimated, and in this respect England will have the great advantage of being able to test thoroughly any improved methods of observation that may be suggested. The erection of the observing huts has also proved useful to a party of officers of the Royal Engineers, who came to the Observatory to practise the observations required for the continuation of the Arc of the Parallel forming the North American boundary.

The Royal Observatory has co-operated in a telegraphic re-determination by means of the French Atlantic Cable of the differences of longitude between Washington, Paris, and Greenwich, undertaken by Professor Hilgard of the United States Coast Survey.

Since the last Report of the Council the Observatory has lost the valuable services of Mr. Carpenter, who resigned his post at the end of last September; after a lapse of more than three months Mr. Downing, of Trinity College, Dublin, has been appointed his successor. The inconvenience of this delay would have been severely felt but for the dismounting of the Altazimuth.

Radcliffe Observatory, Oxford.

The only alteration during the past year in the establishment of this Observatory, consists in the addition of a computer.

The reports of former years will show that the work undertaken was slightly in excess of the powers of the computing forces, and on this being represented to the Board of Trustees, they, with their accustomed liberality, sanctioned for a limited time the additional expense thereby incurred. The establishment of assistants is the same as in former years, Mr. Lucas and Mr. Keating occupying the posts of first and second assistant; and the two computers are Mr. Luff, who has for so many years so zealously assisted

in the reduction of the observations, and Mr. Frederick Bellamy, who has been recently engaged. The good effects of the addition are already very striking, and it is hoped that all arrears of reductions will, in the course of the present year, be almost, if not altogether got rid of.

It will be also gratifying to the members of the Society to learn that Oxford is now included in the list of inland meteorological stations which send daily results by telegram to the Meteorological Office in London; Mr. Lucas, with his usual zeal, having undertaken to forward the necessary observations.

With regard to the astronomical observations of the past year, it will be sufficient to say that they have been carried on with all possible vigour and uniformity, though the wet and gloomy character of the year has contributed, as probably in all other places, to make the numbers considerably smaller than usual. In addition to the ordinary observations with the transit-circle and the heliometer, there have been, however, fourteen observations of occultations of stars by the Moon, besides a large number of observations of phenomena of *Jupiter's* satellites which are printed in the *Monthly Notices* of the Society.

The reductions are going on with vigour. All the transits are reduced to the end of 1872, and the observations of zenith distance will soon be completed to the end of 1871; while all the occultations which have been observed up to the present time, are reduced and ready for press, as well as all other extra-meridional observations.

A great portion of the two-hourly meteorological results for 1870 (as well as a portion, comprising the wind-results for 1871) are reduced to numbers, and it is hoped that in the course of the present year a great portion of the arrears will be got rid of.

Nothing has yet been done towards the compilation of the Third Radcliffe Catalogue, but it will soon be possible to undertake it.

The printing of the volume for 1870 is going on steadily, and some copies of the catalogue of stars for that year (about 1450 in number) will be ready shortly.

Cambridge Observatory.

The new Transit Circle continues to be employed in the observations of the small stars down to the ninth magnitude, included in the zone, lying between 25° and 30° of North Declination, a work which it will require some years to complete.

As was mentioned in last year's Report, this work has been undertaken with the view of assisting in carrying out the plan formed by the German *Astronomische Gesellschaft* for observing all the stars to the ninth magnitude inclusive, contained in Arge-lander's *Durchmusterung des Nördlichen Himmels*.

Since the last Report some alterations have been made in the

mode of observation. At the beginning of the year the instrument was set by the circle observer by means of the tangent screw, and the bisection was made by the transit observer using the other handle of the tangent screw. It was soon found, however, that even within the range of half a degree in declination, this mode of setting the instrument caused too great a delay, and was accompanied by a noise which was somewhat disturbing to the transit observer. In order to obviate this inconvenience, Mr. Graham was led to devise a very simple method of setting the instrument, which has since been employed with perfect success. One end of a cord is looped over the object-end of the telescope, the cord then passes round a pulley placed at the foot of the south collimator pier, thence it passes round a second pulley placed within reach of the circle observer when standing at the pointer microscope, and thence again round a third pulley close to the first, from which it passes to the eye-end of the telescope, round which it is again looped. By simply pulling the cord the instrument can be set in a few seconds with much greater accuracy than is attainable with the usual setting circle at the eye-end. To unclamp, set and clamp again, requires not more than five seconds. The transit-observer then roughly bisects the star by means of the tangent screw, gives the signal for reading off the microscopes, registers the transits across three wires, leisurely bisects with the micrometer-screw, and then reads and records the micrometer-head; the circle observer meanwhile reading off and recording two opposite microscopes and the pointer microscope, and selecting from the working catalogue the next star to be observed. In this way it is found that forty stars per hour can be easily and satisfactorily observed. It will be noticed that the rough bisection only is now made by the tangent screw, the final touches being given with the micrometer screw, which allows the bisection to be made with greater delicacy. Hitherto the zones thus taken have been limited to one degree in breadth, but, if necessary, the breadth could be easily increased. The requisite number of standard stars for clock correction are taken either in the course of the zone or immediately before and after; always in the course of the zone when the night is uncertain, as has been frequently the case during the past year. *Polaris* is regularly observed for azimuthal deviation of the instrument. The level and collimation errors are determined at least twice a week, and the nadir point nearly every day on which observations are made.

An instrumental error, which has caused us much trouble, was detected in October, 1871, in consequence of a suggestion made by Dr. Robinson, of Armagh. When the instrument is turned through the south horizon to the nadir, the reading of the observed nadir point is about $1''.5$ in excess of that which is obtained when the instrument is turned through the north horizon to the nadir. Many experiments have been made to ascertain the cause of this discrepancy. At first it was imagined that the

clamp, by which the eye-piece—which is very weighty—is secured in its place within the telescope tube, might possibly permit a slight amount of shake, and in order to prevent this, three screws were inserted near the end of the telescope tube, so that their ends could be brought to bear on the tube of the eye-piece at some distance from the plane of action of the clamp. The springs which secure the lenses of the object-glass in their cell were also strengthened and made to act independently on the two lenses. The nadir point has been observed with the instrument unclamped, and even with the clamping apparatus entirely removed, and the weights of the counterpoises have likewise been reduced. These alterations, however, seem to produce no appreciable effect on the instrumental error in question. The error is exactly of the same kind as that which would take place if the screws by which the telescope-tube which carries the eye-piece is fastened to the central cube were not perfectly tight. These screws, however, have been forced as tight as can be done with safety, and Professor Adams fears that there is a defect at some point of the tube itself so that it yields to a certain extent and does not recover itself until its weight is brought to act in the opposite direction. If this be the case, the only cure of the evil will be to replace the faulty tube by a new one. Fortunately the error appears to be remarkably constant in amount, and as care is always taken first to direct the instrument to the horizon on the same side of the zenith as that in which it is to be employed, allowance may be made for its effects.

Forms and tables have been prepared for facilitating the reductions, the coefficients for level and collimation errors, and the nadir points are all calculated. The reductions of the standard stars, and the determination of clock corrections, are in progress, and a mode has been devised which will greatly facilitate the reductions to the centre wire of the observations of the zone stars, which are necessarily all broken observations.

The labour connected with the meteorological observations has been somewhat increased, as this observatory has been made one of the stations from which daily telegraphic communications are sent to the Meteorological Office in London.

A very excellent barometer has been procured from Adie, which is mounted in the transit-room.

Royal Observatory, Edinburgh.

During the past year the daily public distribution of time by electric time-ball, time-gun and controlled clocks, has continued as usual, with the addition of a new public controlled clock with its own circle of affiliated clocks in the University of Edinburgh, and a new gun-signal at Dundee; the Edinburgh Observatory's determination of Greenwich time being conveyed to the Dundee gun by the telegraphic system of the General Post Office in Edin-

burgh. The computation of the bi-daily Meteorological Observations at fifty-five stations of the Meteorological Society of Scotland, for the Registrar General's Quarterly and Annual Returns has also been continued in the Observatory.

Further, during the past year the printed Edinburgh observations down to 1870, with portions of 1871, have been distributed; together with a compendious representation of the whole of the meteorological computations for Scotland prepared in the Observatory for the Registrar General from 1858 downwards.

In February 1872, the Edinburgh Astronomer having failed, after formal application, to obtain any assistance from the Government grant to the Royal Society, proceeded at his own expense to Palermo, with a but poorly fitted out spectroscope arrangement of his own construction; and in company with Signors Cacciatore and Tacchini of the Royal Observatory of that southern city, succeeded in making there repeated satisfactory observations of the spectrum of the Zodiacal Light, with a result not in accordance with the views previously held by some very high authorities.

The new equatoreal of two feet aperture for the Edinburgh Observatory by Mr. Howard Grubb of Dublin, was erected in all its larger and more essential parts punctually according to contract towards the end of last month; but is now waiting for some of its finer fittings and subsidiary arrangements, as well as certain necessary alterations to the building before its use commences. What has been done so far, in its main erection, reflects the utmost credit on Mr. Grubb and his men, who toiled through nearly the whole of December, in the darkest and most rainy period almost ever known, putting the instrument together chiefly by the light of hand-lamps, in order that the time-requirements of the contract should be as punctually fulfilled in an astronomical instrument-making contract as in any other.

Dunsink (Dublin) Observatory.

During the past year Dr. Brünnow has continued the observations on the parallax of stars, and he has also observed such double stars as are of special interest on account of their established or suspected orbital motion. The second part of the observations has been printed, and will be published in a few weeks.

Dr. Brünnow has also observed the planet *Phoea* during the months of August and September, using as comparison stars those selected beforehand by Professor Galle, with a view of determining the parallax of the Sun, but it is feared that this labour was lost, as it seems that no corresponding observations were made in the southern hemisphere.

The new meridian-circle which has been ordered from MM. Pistor and Martins, of Berlin, has not yet arrived, owing to some unavoidable delays, but the instrument is now nearly ready, and

is expected soon to be mounted in the Observatory, as all the alterations in the meridian-circle room have been completed during the year, and everything is ready for its reception.

Glasgow Observatory.

The operations at the Glasgow Observatory during the past year have consisted mainly in the reduction of the star observations which have been accumulating for several years, and which it is proposed shortly hereafter to publish. The objects whose places have thus been determined with the transit circle generally range between the sixth and ninth magnitudes, and include about four thousand of the stars in Bessel's zones. The meteors of November 27 were seen under exceptionally favourable circumstances, and it is believed that a fair determination has been obtained of the position of the radiant-point and of the time of maximum of the shower. The system of meteorological observations conducted by means of self-recording instruments, which has been established under the auspices of the Meteorological Committee of the Royal Society, continues in full operation. A quarterly publication, embodying a discussion of the results obtained at the seven affiliated observatories, now issues regularly from the office of the Committee in Victoria Street, Westminster.

Liverpool Observatory, Bidston, Birkenhead.

The work at this Observatory has been chiefly confined to the communication of time to the Port, the testing of nautical instruments, and to meteorological observations.

The arrangements for firing the time-gun, which is placed on the Morpeth Dock Pier Head, about three miles from the Observatory, were formerly such as to cause some trouble in consequence of the controlled clock not being sufficiently powerful for the purpose for which it was intended. Mr. Ritchie has therefore erected a new clock of much greater power in a building a few yards from the gun, and since these alterations have been made the performance of the gun-clock has been satisfactory. The flash of the gun is well seen from the Observatory, and is compared daily with the normal clock, the errors of which, as found from subsequent observations, can be obtained at the Observatory for each day of the year.

Since the new regulations for the trial of chronometers came into operation more than a thousand of these instruments have been tested at the Observatory. The method of trial adopted by Mr. Hartnup is to find the rates of the chronometers in the two extreme and middle temperatures to which they are generally exposed at sea. The chronometers employed in the mercantile navy are almost universally furnished with that which is known as the ordinary compensation-balance; and it is well known that

chronometers with this balance when adjusted for high and low temperatures go faster at the intermediate temperatures than at either of the extremes. To show the amount of error caused by this defect in the ordinary balance in so small a range of temperature as thirty degrees of Fahrenheit it is absolutely necessary to have the means of subjecting the instruments to three definite temperatures; such means have been provided at the new Observatory, and all the chronometers on trial are exposed to definite temperatures in the following order:— 55° , 70° , 85° , 70° , 55° , a change of 15° being made at the end of each week. Abstracts of the rates so found are printed at the end of each year, and the results up to the present time show,—

1st. That the rates of about ten per cent of the chronometers tested are so irregular as to render the instruments quite unfit for nautical purposes.

2nd. That the error of thermal adjustment between the temperatures of 55° and 85° is often such as to cause a change of rate to the amount of many seconds a day.

3rd. That the best made and most carefully adjusted instruments when shown by the trial to have the same rate in 55° and 85° gain on the average six-tenths of a second a day more in 70° than at either of the above-named extremes; and that when they are found to have the same rate in either 55° and 70° , or 70° and 85° , they lose more at the other extreme of 85° or 55° ; the average amount being one second and a half a day.

It will be seen from the above that chronometers which have been carefully adjusted for the temperatures 55° and 70° , or 70° and 85° , are liable between the extremes of 55° and 85° to an alteration in their daily rates of one second and a half for a change of temperature of 15° of Fahrenheit.

Two meteorological telegrams, containing information useful to the shipping interests, are sent daily from the Observatory to Liverpool; weekly meteorological results are supplied to the Medical Officers of Health for Liverpool and Birkenhead, and the Registrar General is supplied with weekly and monthly meteorological results.

Durham Observatory.

During the past year the scheme of observations that has been hitherto pursued has been greatly interfered with by the unsettled state of the government of the Durham Observatory, as well as the very unfavourable weather experienced in the north of England. That scheme embraced the extra-meridional observation of those minor planets whose orbits were imperfectly known, but the necessity for a large instrument to perform this work satisfactorily is yearly becoming greater. Finding the equatoreal more and more inadequate for the work, it appears that the time is now come to discontinue the attempt, and to leave this branch of astronomy to the care of the Continental observatories, which have so perseveringly followed it. It is not without

regret that this statement is made, but it is hoped that the resources of the Observatory may be more usefully employed in other directions. Phenomena of an occasional character will in future form the principal objects of observation. Comets, when discovered, will be observed with the equatoreal, and a few planets will be occasionally followed beyond the limits of the Berlin ephemerides when such observation is likely to advance our knowledge of their orbits. Ephemerides will also be computed for this purpose when necessary, and it is believed that this limitation of work will be approved by astronomers.

The meteorological observations are continued with the usual regularity, and now form the most valuable series in this part of England.

Kew Observatory.

The Photoheliograph was worked regularly up to the end of March, 1872, namely, a month beyond the period originally contemplated, in order to complete the ten years' series of observations. The measurements and reductions of the Sun-pictures are being continued at the expense of Mr. De La Rue; the results for the years 1867, 1868, and 1869, are in course of printing in the *Phil. Trans.* The remainder of the pictures—namely, those of 1870, 1871, and up to March 31, 1872—will be measured and reduced during the current year.

Photographs have been obtained of a scale of equal parts, 15 feet in length, which has been temporarily erected, with the sanction of Her Majesty's Office of Works, on the Pagoda at Kew, distant 4398.24 ft. from the photoheliograph. The divisions of the scale consist of plates and intervening spaces, both exactly 1 foot wide, and consequently subtending an angle of $46''\cdot9$. The measurement of the pictures of this scale, which has been photographed in different positions across a diameter of the field, will serve to determine the correction for optical distortion. In the photographs the straining rods of the structure which carries the plates, and which subtend an angle of only $0''\cdot9$, are well defined.

A photoheliograph for Pulkowa, intended for observations of the transit of *Venus*, was, previous to being sent to its destination, taken to the Kew Observatory, and photographs of the scale were obtained with it. The measurement of these pictures will determine the optical character of the instrument, which has been constructed by Mr. Dallmeyer, and which appears to be nearly, and possibly entirely, free from distortion.

The measurements of the scale-photograms are deferred for a short time, as the micrometer is still in use for the Sun pictures.

Since March, when the Sun-photograms were discontinued, eye-observations of the Sun, after the method of Hofrath

Schwabe, have been made at Kew with a telescope $2\frac{3}{4}$ inches aperture.

The Kew photoheliograph will be shortly erected and worked at the Royal Observatory, Greenwich.

Stonyhurst Observatory.

In consequence of the very cloudy state of the sky during the past twelve months, any continuous series of astronomical observations has been rendered almost impossible.

An attempt is being made to see how far this Observatory might be able to aid in supplying the complete series of observations of the phenomena of *Jupiter's* satellites required for the correct theory of the planet; but, although one of the assistants has devoted considerable time to the subject, the clouds have made all his efforts fruitless.

The continuous registration of every variation of the Earth's magnetism, and of all the most important meteorological changes, made it very desirable to obtain a simultaneous record of the alterations daily taking place on the solar surface, as thus this Observatory might be made a complete physical establishment. Some further steps have been taken this year to ensure the completeness of the arrangements.

A reduction of the whole of our daily magnetic traces, as a preliminary step to the intercomparison of simultaneous solar, meteorological, and magnetic phenomena, has been started this year, and has already made fair progress.

A paper on the results of the Magnetic Survey of the whole of Belgium, made last year with the Stonyhurst instruments, has been communicated to the Royal Society.

Temple Observatory, Rugby.

This is an observatory founded at Rugby in memory of the present Bishop of Exeter, late Head Master of Rugby School. It consists at present of a small wooden observatory, containing the $8\frac{1}{4}$ -inch equatoreal made by Alvan Clark for Dawes, and a $12\frac{1}{8}$ -inch reflector by With, mounted by Mr. Seabroke, and a dark room for spectroscopic work.

The observatory is used for educational purposes, and the work of observing is therefore much interrupted.

Mr. Seabroke has mapped the solar prominences on nearly every day on which the Sun has been visible, and has compared in part the spectra of hydrogen and nitrogen and various low pressures directly with the solar spectrum.

Mr. Wilson and Mr. Seabroke have measured a considerable number of double stars.

Drawings of Sun-spots, Encke's Comet, *Venus*, *Jupiter*, and *Mars*, have been made repeatedly by some of the boys, who also assist in double-star measuring, and in some of the calculations.

Lord Lindsay's Observatory, Dun Echt, Aberdeen.

During the past year the arrangements have been made, and rooms completed for the reception of the following instruments,—

1. A transit circle by Troughton and Simms similar (with some modifications) to the new circle at Cambridge by the same makers. Aperture of object-glass, 8 inches. Focal length, 8 feet, 6 inches. Both circles finely divided, each of 3 feet in diameter, and reading by 8 microscopes.

2. An equatoreal by Grubb of Dublin, somewhat similar to the Royal Society telescope by the same maker, and at present in the hands of Dr. Huggins. Aperture of object-glass, 15 inches, focal length, 15 feet.

3. An equatoreal by T. Cooke and Sons of York, of 6 inches aperture, and 6 feet focal length.

4. A heliometer, of 4 French inches aperture by Repsold of Hamburg. This instrument is exchangeable with the telescope of the Cooke equatoreal, so that either the one or the other can be used on the same stand.

5. A silver on glass Newtonian reflector of 13 inches aperture (formerly Mr. Gill's telescope), equatorially mounted, focal length, 10 feet, 6 inches. This instrument has also Cassegrain mirrors, equivalent to a focal length of 40 feet.

6. A large chronograph with four barrels.

7. An altazimuth by Troughton and Simms, with circles of 12 inches in diameter.

Besides these there are, in course of construction, a large "Foucault Siderostat," a portable transit, and some minor instruments for which as yet no buildings have been erected.

Excepting the 12 inches altazimuth, none of the other instruments have yet been received from the makers.

The Grubb equatoreal should have been completed last September. The stand and tube are finished, but it was not until July last year, or eleven months after the order was given, that Mr. Grubb succeeded in obtaining from Messrs. Chance two sufficiently perfect discs of glass.

Mr. Grubb hopes to have the instrument ready for trial by the end of February.

The heliometer is promised by Messrs. Repsold in September.

The reflector is having various alterations made upon it by Mr. Grubb, to adapt it for solar photography, for use in the latitude of the Mauritius.

The transit-circle should have been completed and erected long ago, but the makers seem to have encountered some unforeseen causes of delay.

The mirrors of the Siderostat have been completed in the

National Observatory of Paris, by Monsieur Martin and have been very highly reported on.

The work of the past year has chiefly consisted in the completion of the various buildings, piers, shutters, domes, etc : the planning of instrumental and observing details, and in experiments and arrangements for the observation of the transit of *Venus* at the Mauritius in 1874.

An approximate determination of the latitude has been made by observations of *Polaris* with the altazimuth, giving a result of

$$57^{\circ} 9' 36'' \text{ N.}$$

The Astronomer's house, and laboratory, will be completed by the end of June, by which time it is believed that most of the instruments will be erected and adjusted, and Lord Lindsay and Mr. Gill hope then to begin systematic work.

Mr. Barclay's Observatory, Leyton.

During the past year the principal work has been the measuring of the angles of position and distances of double-stars, binary, and those suspected of motion. These observations are intended to form Vol. III. of the *Leyton Observations*, and it has been thought by Mr. Barclay that the more frequent publication of the observations would be acceptable, for though the book would necessarily be small (Mr. Talmage being alone in charge of the observatory), the rapid publication of reduced observations commends itself to all.

Comets, occultations, and phenomena of *Jupiter's* satellites, are also observed with the 10-inch equatoreal.

The instrumental part of the observatory is the same as described in Vols. I. and II. of the *Leyton Observations*, with the exception that gas is now "entirely" used to illuminate the field of the equatoreal, oil being dispensed with.

Different-coloured glasses (white, yellow, and red) have been used to colour the field, for it has been found that in different states of the atmosphere, a "small" star may be better seen, or a "close" star better divided, with, for instance, a yellow than with a red field.

Mr. Buckingham's Observatory, East Dulwich.

The large refractor, of $21\frac{1}{4}$ inches clear aperture, has been employed during the past year in the examination of the physical appearance of the planets, but owing to Mr. Buckingham's frequent absence, and the unusually cloudy state of the weather during the last six months, very few observations have been made. Some measures of *Jupiter*, *Neptune*, and double-stars

have, however, been observed; some of the latter, whose components are very close, have been divided for the first time. Mr. Buckingham took advantage of some brilliant days in April, May, and June, 1872, to observe *Jupiter* in daylight, with his great refractor, using the full aperture. The contrasts of colour on his surface and the belts were better seen than by night. On several occasions, notably on May 5, at 4 P.M., and on June 1, at 1 P.M., the satellites were seen.

The great refractor has also been employed in a scrutiny of the trapezium in the nebula of *Orion*, both with high and low powers; no trace, however, of any star can be seen within it. On favourable occasions, Mr. Buckingham has devoted particular attention to the examination of the solar surface, and more especially of the bright granules, which evidently play so important a part in the illuminating power of the Sun. Mr. Buckingham hopes that he will soon be in a position to lay the results of his observations before the Society. The Moon's surface has also been occasionally examined.

The instruments now in use at this observatory are a transit-instrument of 3 inches aperture, by Troughton and Simms, the great refractor, a good chronograph, and an excellent sidereal clock. The equatoreal, with a 9-inch object-glass by Wray, driven by a clock devised by Foucault, and made by Secreten, of Paris, has been lately dismantled.

Mr. Knott's Observatory, Woodcroft, Cuckfield.

Observations of variable stars have been continued during the past year. At the end of February a maximum of *U Geminorum* was observed, on which occasion the star remained for twelve days of and above the 10.3 magnitude.

Measures with the wire micrometer of a few double-stars have been also obtained.

A persistent rainfall and heavy ground mists have much interfered with observatory work.

Royal Observatory, Cape of Good Hope.

The attention of the staff has been chiefly directed to the reduction and printing of the observations made with the transit-circle, 1856-61. The results for 1857-58 have been printed and forwarded to England for distribution. The results for 1859 are printed to the end of the Star Catalogue. The whole of the star reductions for 1860 are ready for press. A general catalogue has been formed from the star observations, 1856-1860. The few Southern stars observed in 1861 out of the range of the Northern observatories have also been included. The catalogue contains 1159 stars, and is com-

plete, except the secular variations and the proper motions of some of the stars.

The Star Ledger for 1871 is ready for press. The catalogue of close circumpolars has been forwarded to the Society for publication, and appears in the *Monthly Notices* for November, 1872. More than 200 stars between 165° and 175° N.P.D. have been observed during the year 1872. The stars have been, with few exceptions, observed three times. The November meteors were carefully looked for during many nights about November 13, but the sky was generally clouded, and but very few could be seen.

Many meteors however appear to have been seen in parts of the Colony where the sky was clear, but no observations have been received to fix the radiant-point.

A return-signal has been arranged for after the drop of the Port Elizabeth time-ball. The distance over which the wires are carried is nearly 600 miles. The return-signal reaches the Observatory from $\frac{3}{10}$ to $\frac{6}{10}$ of a second after the current leaves the Observatory.

The instrumental equipment of the Observatory is in many respects defective, but some additions are under the consideration of the Lords of the Admiralty. The work of the Observatory has been much impeded by serious illness amongst the staff, and the long delay which has taken place in filling up the third assistantship, which has been vacant more than two years.

Melbourne Observatory.

During the year preceding Mr. Ellery's Report to the Board of Visitors for 1872, the transit-circle had been employed for the most part in observing stars for clock-error and for the determination of the position of the instrument. All the R.A. observations were completely reduced, and those for N.P.D. nearly so to the end of 1871.

A general catalogue of stars resulting from all the meridional observations made at this Observatory has been for some time in preparation. This has been found to be a most laborious and tedious work; but it is now far advanced towards completion. The year 1870 has been adopted as the epoch of the catalogue.

The observation of the Melbourne Zones of the Southern Survey has been suspended, as the calculations were getting too far behind. The number of small stars observed at this Observatory, on account of the Survey, amount to 48,672, and the number reduced to 36,917.

The great equatoreal has been employed on miscellaneous observations, including measures and drawings of the nebula and stars near α *Argus*, observations of *Sirius* and companions, of *Venus*, *Jupiter*, and *Saturn*, *Antares*, H. 3722, 30 *Doradus*, *Orion*, *Rigel*, *Achernar*, and *Canopus*. Every favourable oppor-

tunity has also been taken for scrutinising the Moon's surface, for revision of the lunar maps of the British Association Committee.

Mr. Ellery states that the work with the Great Melbourne Telescope has been much impeded by bad weather, moreover, that the Observatory has been without an observer for three months, Mr. Le Sueur's successor having resigned, and that he has had to work the Great Telescope himself; a new observer was about to be appointed about the middle of December last. Both the large mirrors require repolishing, but Mr. Ellery does not mean to attempt this critical work until he can command with comparative certainty the production of the parabolic figure; in the meantime, however, he has been giving much time to the experimental figuring of 12 and 9-inch mirrors, and has thus gained much experience in the management of figure especially with the aid of Foucault's method of testing, which he has adopted. He states, under date of Dec. 6, 1872, "I have got a magnificent 9-inch finished, and the polish is exquisite; it was obtained with a polisher made with the grinder covered $\frac{1}{20}$ of an inch with a mixture of 1 part rosin and 4 of bees'-wax, *scraped* until in contact everywhere with the speculum. The surface is like quick-silver, the blackest polish I have ever seen, without any trace of *scratches*; it performs with 600 admirably." It is evident that Mr. Ellery is on the right track, and that he will soon feel confidence in attacking the repolishing of the large mirrors.

It will be recollected that Mr. Ellery sent over last year an enlarged positive copy of a photograph of the Moon, obtained with the Great Melbourne Telescope, which is now suspended in the meeting-room of the Society. The bad weather has prevented him from doing much in photography with the large telescope since the date of that picture. But he has made very promising pictures of the Sun by means of a $4\frac{1}{2}$ -telescope and an ordinary Huyghenian eye-piece, which enlarged the image to 5 inches in diameter. A picture of the Sun thus obtained on October 9, 1871, has been sent over, and is now with the Society. Mr. Ellery, however, intends trying a Steinheil's achromatized (ac-tinically?) positive, that he possesses, with the view of obtaining more perfect pictures.

Lastly, Mr. Ellery has sent a negative photograph on glass of several drawings of the nebula in the neighbourhood of *Argus*. These drawings have evidently been made with great pains to ensure accuracy, and are very interesting. Astronomers will look forward with great interest to future observations of this nebula made with the mirrors when restored to the polish which they originally had when they left the hands of Mr. Grubb.

The material for volume iv. of the *Melbourne Astronomical Observations* is now in the press. The ordinary magnetical and meteorological observations have been regularly carried on without any notable change of method.

Sydney Observatory.

The general condition of the Observatory is considered to be in a much more satisfactory state than formerly, and the public interest manifested in astronomy, as shown by the number of amateur astronomers, with useful telescopes, is steadily increasing.

During the past year the transit instrument has been devoted to the usual meridional observations, including those of the Moon, and Moon-culminating stars, which were observed as often as possible. The equatoreal has been employed in the observation of the angular distances and positions of double-stars, and in the construction of a map of the nebula and stars about *Argús*. A photographic apparatus has been fitted to the instrument, and some good pictures of the Moon obtained.

The Sydney time-ball has worked steadily throughout the year, and the clock arrangement in connexion with the chronograph, on which the clock-signal and the return-signal from the ball are both recorded, has worked satisfactorily. Signals by the same contact have been regularly sent to the Newcastle time-ball, but owing to the length of wire (about 100 miles), many interruptions have occurred.

The difference of longitude between this Observatory and the town of Orange, about 150 miles from Sydney, has been carefully determined by galvanic signals. The latitude of Orange was also determined.

The number of meteorological stations in New South Wales has been increased to forty-two. The results from all these stations have been published monthly, and an abstract at the end of the year. The results from the principal stations are also published in the daily papers.

The self-recording meteorological instruments at Sydney, consisting of a barograph (photographic), an anemometer, two rain-gauges—one on the ground, and the other at an elevation of 65 feet—and the tide-gauge, have all worked satisfactorily. The self-registering tide-gauge at Newcastle has also worked satisfactorily, and it has recorded more earthquake waves than at Sydney, owing probably to the fact that the harbour is more open.

Some important experiments on evaporation have been carried on during the year. Magnetic observations have also been made at this Observatory, and at several country stations. A meteoric stone, weighing 145 lbs., which fell near Deniliquin some years since, has been secured, and is now deposited in the Observatory.

Mr. Russell took an active part in the organization of the Australian Expedition for the observation of the Solar Eclipse of December 11–12, 1871. It is already known that cloudy weather unfortunately prevented any observations being taken.

Preparations are being made for the observation of the transit of *Venus* in 1874 by the staff of this Observatory. It is intended

to erect two temporary observatories for the purpose—one near the south-east point of the Colony, and the other on the mountains west of Sydney. The Government of New South Wales have devoted 1000*l.* for the construction of the buildings, and for the purchase of the new instruments required for the observations.

NOTES ON SOME POINTS CONNECTED WITH THE PROGRESS OF
ASTRONOMY DURING THE PAST YEAR.

Discovery of Minor Planets.

Twelve minor planets have been discovered since the last Annual Report, as follows:—

- (118) *Peitho*, discovered at Bilk by Dr. R. Luther on 1872,
March 15.
- (119) , discovered at Ann Arbor, Michigan, by Mr. Wat-
son, on April 3. This planet was observed by M.
Paul Henry, of the Observatory of Paris, on April 9,
before the discovery was announced in Europe.
- (120) *Lachesis*, discovered at Marseilles by M. Borelly, on
April 10.
- (121) , discovered at Ann Arbor, by Mr. Watson, on
May 12.
- (122) *Gerda*, discovered at Hamilton College, Clinton, New York,
by Dr. C. H. F. Peters, on July 31.
- (123) *Brunhilda*, discovered also by Dr. Peters on July 31.
- (124) *Alcestis*, discovered by Dr. Peters on August 23.
- (125) , discovered by M. Prosper Henry, at the Observa-
tory of Paris, on September 11.
- (126) , discovered by M. Paul Henry, at Paris, on Novem-
ber 5.
- (127) , discovered by M. Prosper Henry, also at Paris, on
November 5.
- (128) , discovered by Mr. Watson, at Ann Arbor, on
November 25. This planet was independently ob-
served by M. Borelly before the announcement in
Europe of its discovery by Mr. Watson.
- (129) , discovered by Dr. C. H. F. Peters, at Clinton,
New York, on 1873, February 5.

The minor planets continue to be observed on all favourable occasions at Greenwich and Paris, according to the convention originally agreed upon by the Astronomer Royal and M. Le Verrier, and at some of the principal Observatories, both in Europe and America. Special notice may be taken of a volume which has lately appeared, containing the results of the observations of 48 minor planets, observed in 1871 by Dr. Möller, with the equatoreal at the Lund Observatory; the volume also contains

the results of the observations of the comets of Winnecke, Tempel (1), Encke, Tuttle, and Tempel (2), all of which were visible during that year.

The planet ⁽¹¹⁵⁾ discovered on August 6, 1871, and unnamed at the date of the last Report, has received the name of *Thyra*.

Galvanic Determinations of Longitude.

The third volume of the series of chronographic determinations of the differences of longitude between certain stations in various parts of Switzerland, made under the control of the Geodesic Commission of that country, has lately been distributed. In the last Annual Report a notice was given of these operations, and especially of the determinations of the difference of longitude between Neuchâtel and the Righi-Kulm, and between Neuchâtel and Zürich, from the observations of MM. Plantamour and Hirsch, the results of which formed the second volume of the series. The recently published volume contains the details of the observations and reductions of similar determinations between the Observatory of Neuchâtel and an astronomical station at Weissenstein, and between the Observatories of Neuchâtel and Berne. The first of these operations was undertaken in 1868, and the second in 1869. The observations appear to have been made in the same exact manner as on previous occasions, the signals being registered on the chronograph, both directly by the clock, and by the observers of simultaneous transits of stars. The resulting difference of longitude between Neuchâtel and Weissenstein from twenty determinations, is $2^m 13^s.088$, with a probable error of $0^s.018$; and between Neuchâtel and Berne from twenty-four determinations, $1^m 55^s.806$, with a probable error of $0^s.008$.

The velocity of the galvanic current was found respectively to be about 7840 and 9000 miles per sidereal second.

The difference of longitude between London and Teheran in Persia, was determined in the latter part of 1871, and a considerable interest was taken in the operation. The galvanic current was sent through the wires of the Indo-European Telegraph Company. Col. Walker, R.E., taking advantage of his temporary residence in England, arranged with Major St. John, R.E., who is connected with the Persian Telegraph department, an exchange of signals for the purpose of obtaining an approximate value of the longitude for the correction of the maps of Persia. The experiment was perfectly successful, and although the current had to pass along 3870 miles of wire, having five automatic relays at five intermediate stations, the retardation in either direction was found to be under half a second. The resulting value for the longitude of Teheran is $51^{\circ} 24' 56''$, which very nearly agrees with an independent value determined by Major St. John, by combining the previously observed difference of longitude between Teheran and

Kurrachee with that between Kurrachee and the Madras Observatory, as found by the Great Trigonometrical Survey of India. The Greenwich times of the signals were ascertained from the clock in the Central Telegraph Office, which is controlled by the Normal Mean Time Clock at the Royal Observatory. The Teheran local times were obtained from sextant observations made by Major St. John and Captain Pierson, R.E.

Another very important series of observations for the chronographic determination of longitude was made by officers attached to the United States Coast Survey during the summer and autumn of the past year. The plan of operations consisted of a very elaborately-arranged series of observations for determining the difference of longitude between Europe and America. The route adopted in this instance differed from that used by Dr. Gould in 1866. The superintendence of the European end of the operation was intrusted to Mr. J. E. Hilgard. For the purpose of connecting the Observatories of Greenwich and Paris with the experiment, it was necessary to make several independent determinations: first, the signals were transmitted between Greenwich and Brest, by way of Paris; secondly, between Paris and Brest; then between Greenwich and Paris; and finally, between Brest and a station on the coast of America, which was subsequently connected with the Washington Observatory, the signals passing across the Atlantic by the submarine cable of the Société Transatlantique Française. The observations were spread over a considerable time, as Mr. Hilgard was anxious to make each determination depend upon several nights' observations, when a sufficient number of corresponding clock-stars were observed at each station. This experiment having been concluded only late in the autumn, the results are not yet published. Mr. Hilgard, who has returned to the United States, is, however, actively employed on the reductions, and it is expected that the results will soon be made known.

In the early part of last year M. C. Von Littrow presented to the Vienna Academy of Sciences a detailed report on the longitude operations, carried out in 1865 by MM. Bruhns, Förster, and Weiss, to connect the Observatories of Berlin, Leipzig, and Vienna. Signals were transmitted on several days between the different stations, and the greatest care has been taken in the reductions, including the determination of the value for personal equation between the observers. The final results for longitude, which are in every way satisfactory, are as follows:—

Leipzig west of Vienna	..	..	..	^m ^s 15 57.674
Berlin west of Vienna	..	..	..	11 56.775
Leipzig west of Berlin	..	..	..	4 0.899

Dr. Gould and Señor Moneta, chief of the Corps of National Engineers, have been engaged upon two series of longitude-determinations between the Observatory of Cordoba and the cities of Rosario and Buenos Ayres. Time-signals were exchanged between these places on several nights, the results of which have indicated that the position of Cordoba on the best maps is in error more than a minute of time, and that it ought to be placed more towards the west by that quantity. Dr. Gould remarks that the telegraph-wires across the Andes to Chili were completely fixed last summer, and that arrangements are making for the determination of the difference of longitude between Cordoba and Santiago. As the longitude of the long-established Observatory of Santiago, referred to European meridians, is probably well known, Dr. Gould expects that the proposed undertaking will not only give a trustworthy result for the longitude of Cordoba, but that it will also correct the adopted values for Buenos Ayres, Rosario, and Montevideo.

Munich Zone-Catalogues of Stars.

Another instalment of Dr. Lamont's valuable zone-catalogues of small stars has appeared during the last year. This work, which at present consists of four catalogues, will be of great use to observers of comets and minor planets, supplementing the more extensive zone observations of Argelander and Bessel. All the right ascensions and declinations are given for the epoch 1850. The greater number of the stars are of the eighth and ninth magnitude, and a few of the tenth. The four catalogues include the zone of the heavens between 9° north declination and 15° south declination. The first portion of the work, and by far the largest of the catalogues, was published in 1866, containing 9412 equatorial stars, all situated within three degrees on each side of the equator. The second catalogue, published in 1869, is formed of 6323 stars included in the zone from 3° to 9° north declination; the third, published also in 1869, contains 4793 stars from 3° to 9° south declination; the fourth, or that lately published, gives the places of 4093 stars between 9° and 15° south declination, the complete number being 24,621 stars. From an irregular comparison of a few of the places with those given in the Greenwich catalogues, it was satisfactory to find that the Munich and Greenwich right ascensions and declinations were generally accordant. Dr. Lamont has, however, himself made a careful comparison of these elements contained in all the four catalogues with those corresponding in the catalogues of Lalande, Weisse's-Bessel, Rümker, and Schjellerup. On the whole, they agree fairly, excepting in cases where there is an evident error made in the observations. At the end of the last catalogue, Dr. Lamont has also given a series of tables containing a detailed statement of the errors and rates of the clock for the whole period of the observations, or from January 27, 1821, to November 10, 1868.

Gilliss' Catalogue of 1963 Stars.

This excellent catalogue, consisting principally of stars south of the equator, is formed from observations made by the late Capt. Gilliss at Santiago, during his astronomical expedition to Chili in the years 1849-52. Four quarto volumes of the results of this expedition were published under the superintendence of Capt. Gilliss, and the observations used in the formation of this catalogue were intended by him to occupy another volume of the series. Owing, however, to his death, the work of reduction was necessarily stopped, and all the calculations and papers were deposited in the United States Naval Observatory for safe keeping. As the whole of the funds devoted to the expedition were exhausted, and as there appeared no probability that the work would be completed on the original plan, Commodore Sands, the Director of the Observatory, deemed it desirable in the interests of astronomy to publish the catalogue only, as an appendix to one of the volumes of the *Washington Observations*. The adopted epoch of the catalogue is January 1, 1850. A very large number of the right ascensions and declinations of the stars depend upon a single transit, but from the care taken in the observations, and the excellence of the instrument employed, it is very probable that the errors of the results are small. Most of the places of the fundamental stars which had been used for the determination of the errors of the transit-clock, and the error of azimuth, depend upon a very large number of observations. Astronomers are indebted to Commodore Sands for giving them a work which forms a very valuable addition to our catalogues of Southern stars.

The Right Ascensions of Equatoreal Fundamental Stars.

A valuable Memoir by Professor Newcomb, "On the Right Ascensions of the Equatoreal Fundamental Stars, and the corrections necessary to reduce the Right Ascensions of different Catalogues to a Mean Homogeneous System," has been published as Appendix III. (pp. 5 to 73) of the *Washington Observations* for 1870. The object is to do for the right ascensions of the equatoreal and zodiacal stars, on which the reductions of lunar and planetary observations depend, what had been done by Dr. Auwers for the declinations, namely, to furnish the data necessary to reduce the principal original catalogues of stars to a homogeneous system, by freeing them of their systematic differences. This is effected by comparing the catalogue positions of the fundamental stars with a uniform set of standard positions, as free as possible from systematic error; and by considering any systematic discordance between the standard and the catalogue position as due to error of the latter, and correcting it accordingly. Twelve catalogues, commencing with Auwers' Bradley, 1755, and ending with the Washington Catalogue for 1870,

are employed in the determination, and from these are obtained the systematic corrections to be applied to the right ascensions of different catalogues. Finally, applying the corrections to the catalogue positions, there are deduced definitive corrections to the individual right ascensions of thirty-two fundamental stars, exhibited in a table, "Definitive Corrections to Right Ascensions of *Tabulæ Regiomontanæ*," and the mean right ascensions are thence calculated for the beginning of each fifth Besselian fictitious year, 1750-1850. The author conceives that the mean error of these right ascensions, after correction for equinox, will not exceed $0^s.010$ at any time during the nineteenth century.

The Masses of the Planets and the Solar Parallax.

M. Leverrier has communicated to the Paris Academy an important paper on the determination of the solar parallax from the mass of the Earth. The latter element can theoretically be determined from the inequalities in the motions of *Venus* and *Mars*; and the question Leverrier has considered is simply whether the time has yet arrived when the value of the Earth's mass can practically be determined with sufficient accuracy from the motions of the planets to afford an independent means of ascertaining the value of the solar parallax. He arrives at the conclusion that the time really has come when the Earth's mass should no longer be deduced from the solar parallax, but derived directly from the motions of the planets. But he indicates certain conditions under which it would be necessary to assume that the attraction exerted by masses hitherto regarded as extremely small is more considerable than has been supposed. Thus, if the motions of the celestial bodies should give a value to the solar parallax exceeding by $\frac{1}{10}$ th of a second of arc that deduced from observations of the transit of *Venus*, or from the determination of the velocity of light, the difference might be attributed to the attraction of the minor planets, and the amount of this attraction measured; whereas, if the discordance in the value of the solar parallax were only $\frac{1}{100}$ th of a second, the inference would be that the total mass of the minor planets is too small to be measured. M. Leverrier invites the attention of astronomers to the necessity of—

- (1.) An endeavour to ascertain more accurately than at present the masses of various parts of the solar system.
- (2.) Fresh measurements (direct) of the velocity of light.
- (3.) A redetermination of the constant of aberration.
- (4.) The determination of the solar parallax by means of transits of *Venus*, with such accuracy that the astronomer may be able to regard it as true within $\frac{1}{100}$ th part of a second of arc.

"With this limit of extreme precision," M. Leverrier remarks, "the labour becomes one of the most delicate works of art, and

one which ought only to be confided to men who have given special guarantees of their devotion to the enterprise, and have themselves resolved to carry out the observations."

Motions of Stars in the Line of Sight.

Dr. Huggins has been able to extend his observations in this difficult branch of astronomical research. It will be remembered that with the telescope formerly used by him, the star *Sirius* alone was found to be sufficiently bright to be profitably observed by the spectroscopic method for determining motions of recession or approach. Now that Dr. Huggins has at his command a much more powerful telescope he has resumed the inquiry, and with success. It must not be supposed, however, that even now the observations by this method are easily made, or can be extended to any but the brighter stars. This will be understood from the following remarks in Dr. Huggins' report to the Royal Society:—"Even when spectroscope C, containing four compound prisms, and a magnifying power of 16 diameters, are used, the amount of the change of refrangibility to be observed appears very small. The probable error of these estimations is therefore large, as a shift corresponding to five miles per second (about $\frac{1}{40}$ of the distance of D^1 to D^2), or even a somewhat greater velocity, could not be certainly observed. The difficulty arising from the apparent smallness of the change of refrangibility is greatly increased by some other circumstances. The star's light is faint when a narrow slit is used, and the lines, except on very fine nights, cannot be steadily seen, in consequence of the movements in our atmosphere. Further, when the slit is narrow, the clock's motion is not uniform enough to keep the spectrum steadily in view; for these reasons I found it necessary to adopt the method of estimation by comparing the shift with a wire of known thickness, or with the interval between a pair of close lines. I found that, under the circumstances, the use of a micrometer would have given the appearance only of greater accuracy. I wish it, therefore, to be understood, that I regard the following estimations as provisional only, as I hope, by means of apparatus now being constructed, to be able to get more accurate determinations of the velocity of the motions."

The results of Dr. Huggins' observations will be found recorded in an abstract in the last volume (xxxii.) of the *Monthly Notices*. To what is there stated we may add the following remarks by Dr. Huggins, as illustrating the bearing of his method on the determinations of stellar proper motions in right ascension and declination. "Although," he says, "it was not to be expected that a concurrence would always be found between the proper motions which indicate the apparent motions at right angles to the line of sight and the radial motions as discovered by the spectroscope, still it is interesting to remark that in the case

of the stars *Castor* and *Pollux*, one of which is approaching and the other receding, their proper motions also are different in direction and in amount; and further, that γ *Leonis*, which has an opposite radial motion to α and β of the same constellation, differs from these stars in the direction of its proper motion. . . . Mr. Proctor has brought to light strong evidence in favour of the drift of stars in groups having a community of motion by his graphical investigation of the proper motions of all the stars in the catalogues of Mr. Main and Mr. Stone. (The probability of the stars being collected into systems was early suggested by Michell and the elder Herschel.) One of the most remarkable instances pointed out by Mr. Proctor relates to the stars β , γ , δ , ϵ , ζ of the *Great Bear*, which have a community of proper motions, while α and η of the same constellation have a proper motion in the opposite direction. Now, the spectroscopic observations show that the stars β , γ , δ , ϵ , ζ have also a common motion of recession, while the star α is approaching the Earth. The star η , indeed, appears to be moving from us, but it is too far from α to be regarded as a companion to that star."

It is manifest that if the new method can ever be extended to the fainter stars (of those visible to the naked eye), it will afford a means of determining in many cases whether star-drifts recognised from the proper motions in right ascension and declination are apparent only or real.

The Evidence respecting a Resisting Medium in Space.

Professor Asaph Hall has recently discussed afresh the question whether the motion of Encke's comet affords evidence of the existence of a resisting medium in space. "Besides the interest belonging," he writes, "to all periodic comets since the establishment of the probable connexion of their orbits with those of meteoric streams, this comet has a peculiar interest, since from the singular anomaly in its motion Professor Encke drew his inference of a resisting medium in space. Encke's labours on the orbit of this comet were begun in 1819; and immediately after his discovery of its periodicity, he found by comparing the observations of that year with those of 1786, 1795 and 1805, and taking careful account of the planetary perturbations, the remarkable circumstance that the periodic times were diminishing. The following values of these times were found:—

1786-1795	periodic time	=	1208 [·] 112	days.
1795-1805	"	=	1207 [·] 879	"
1805-1819	"	=	1207 [·] 424	"

In order to account for this diminution Encke adopted the hypothesis of a resisting medium in space. He appears to have been led to this hypothesis in the first place on account of its inherent

probability, and in this view he was sustained by Olbers. But the strongest proof of its truth lies in the fact that the analytical investigation shows, that a tangential force resulting from a resisting medium would produce secular changes in the mean motion of the body and in the eccentricity of its orbit, leaving the other elements unchanged or changed by periodic inequalities only. This conclusion is independent of the law of density of the medium. Now this was what Encke needed in order to account for the anomalous motion of the comet, the change falling almost entirely on its mean motion, that of the eccentricity being quite insignificant. Other hypotheses were suggested to explain the diminution of the periodic time, and especially that of internal changes in the comet itself, but nearly all of these, besides being less simple than the assumption of a resisting medium, would necessitate the introduction of forces acting in various directions, and producing anomalous changes in all the other elements of the orbit, contrary to what was required by the observations. Encke, therefore, notwithstanding the doubts of Bessel and other astronomers, continued steadfast in his theory of a resisting medium in space, and for more than forty years, and until within a short time before his death in 1865, pursued his calculations with wonderful zeal and industry. Between the years 1829 and 1859, he published in the volumes of the Berlin Academy eight memoirs on the orbit of this comet, and also other investigations on the same subject in the *Astronomische Nachrichten* and in the *Berliner Jahrbuch*. He assures us, what we can easily believe, that he spared no labour and despised no precaution that could give completeness and surety to his computations; and besides being an excellent mathematician, Encke possessed, in a degree rarely equalled, the skill of adapting formulæ to convenient and safe forms for numerical calculations. He has given in the *Berliner Jahrbuch* for 1861 a *résumé* of his labours; and the proofs presented there, taken simply by themselves, seem to put beyond the shadow of a doubt two conclusions: first, that the periodic time of this comet is diminishing; and, secondly, that this diminution is satisfactorily accounted for by the assumption of a resisting medium in space.

“I will now state the reasons that throw doubt on the preceding conclusions, and which, I think, require that Encke’s results should be tested by an independent calculation.

“The position and dimensions of the orbit of Encke’s comet are such that the comet can approach very near to *Mercury* — so near, indeed, that notwithstanding the small mass of this planet, the perturbations which it may produce in the motion of the comet can exceed the greatest ever produced by *Jupiter*. On account of the rapid motion of *Mercury* the calculation of these perturbations would be very laborious, and frequent corrections of the comet’s elements would be necessary. It is well known that among the incidental results of Encke’s investigations on the orbit of this comet, were the corrections of the values of the

masses of *Jupiter*, *Mars*, and *Mercury*, given by Laplace. The value of the mass of *Jupiter* is now accurately known, but with regard to *Mars* and *Mercury* there is an uncertainty which, of course, it would be necessary to consider in any investigation where these masses can produce large disturbances. Considering, therefore, the great difficulty of the problem, it does not seem unreasonable to ask, before accepting any extraordinary assumption, that Encke's results should be verified by a new calculation, carried on at least through four or five successive revolutions of the comet during the recent times, when the observations have been accurately made. Encke himself has given in the *Berliner Jahrbuch* for 1858 a new and rigorous method for such calculations.

"But should it be found, as seems probable, that Encke's numerical results are correct, it would not follow that the existence of a resisting medium in space is established.

"There are two other periodical comets whose motions have been carefully investigated, and which furnish important evidence on this question. These are Faye's and Winnecke's comets, discovered, or in the case of the last re-discovered, in 1843 and 1858, and which have periods of $7\frac{1}{2}$ and $5\frac{1}{2}$ years respectively. If we denote by q the perihelion distance of a comet, by a its semi-major axis, and by e the eccentricity of its orbit, and express these quantities in units of the Earth's mean distance from the Sun, we shall have the following values for 1858, when all these comets were observed :

Comet.		q .	a .	e .
Encke	..	0.3407	2.2181	0.8464
Faye	..	1.6942	3.8137	0.5556
Winnecke	..	0.7684	3.1367	0.7550

"If we observe that the aphelion distance is $2a - q$, the preceding quantities will give us an idea of how differently situated in space are the orbits of these three comets, and with what different velocities they move around the Sun. Thus, while Encke's comet at its perihelion approaches nearer to the Sun than *Mercury*, and always remains nearer than *Jupiter*, on the other hand, Faye's comet never approaches so near the Sun as does the planet *Mars*. Should it be found, therefore, that all these comets exhibit in their motions the anomaly found by Encke, and could this be accounted for by the assumption of a resisting medium in space, the evidence would be considered decisive. Such, however, is not the fact."

Professor Hall proceeds to discuss the evidence derived from the motions of these two comets, showing that so far as observation has yet gone these bodies would seem to have been altogether unretarded, the agreement between the observed and computed places having been remarkably exact. "Hence," he concludes, "so far as the motions of comets have been determined, the

evidence is against the theory of a resisting medium in space. Thus far the observations of the planets lead to the conclusion that their motions are in strict accord with the law of gravitation; and in the disputes about the acceleration of the mean motion of the Moon no one has thought to seek its cause in a resisting medium; but much more probable causes are at hand. Encke's comet, therefore, stands alone in the strange anomaly in its motion which the calculations have shown. . . . If it be proved that the diminution of the periodic time actually exists, this anomaly must be considered as a peculiarity of Encke's comet, and its cause must be sought for in something which distinguishes this comet from all others. It was early pointed out—by Olbers, I think—that this comet moves through those regions where the zodiacal light is seen. Possibly, also, the numerous meteoric streams which are moving around the Sun, and which are closely connected with the orbits of some of the comets, may exert an influence on their motions."

Flying Shadows during Solar Eclipses.

It has been noticed during total solar eclipses, that singular undulations of light sometimes occur just before and just after the total phase. Dr. Oudemans communicates the following observations of these flying shadows, as observed during the eclipse of December 1871:—

"The 'flying shadows' were very remarkable at Buitensorg; they were observed by persons wholly unacquainted with the phenomenon. They were seen by Mr. Bergsma on a white wall directed E. $13^{\circ} 30'$ N. to W. $12^{\circ} 30'$ S., and on a sheet of white paper lying on a table. On the wall the shadows were inclined to the west, making with the horizontal line an angle according to one observer's measurement of 40° , and according to another's, of 45° . They moved from E. to W. On the white paper they made an angle of 45° with the edges, which were perpendicular to the wall; they moved on the paper from S.E. to N.W. The phenomenon did not show itself as it is represented in Secchi's *Le Soleil*, p. 158. The shadows had a breadth of five to six centimetres; they were limited by lines with small irregular undulations; they were separated by regularly illuminated bands; the distance of the shadows was, according to Dr. Scheffer (the botanist) $1\frac{1}{2}$ decimetres, and, according to Mr. Lang, about three decimetres or a foot. They moved parallel to themselves slowly; their velocity over the wall was about that of a horse in a moderate trotting pace. Mr. Bergsma saw the shadows from about three minutes before totality. During totality they were not visible, according to Mr. Lang, whom Mr. Bergsma had requested to pay particular attention to this point; only Mr. Lang saw now and then a slight change in the intensity of the light on the paper. Immediately after totality the shadows appeared again,

increasing and diminishing alternately in strength, but growing gradually less and less distinct, although Mr. Bergsma continued to see them till about five minutes after totality.

“Mr. Bergsma now describes the means proper to obtain more reliable observations on future occasions. By construction and calculation I have deduced from Mr. Bergsma’s data as to the direction of the shadows on the wall and the paper the following:—

“I assumed the inclination of the lines on the wall to be $42\frac{1}{2}^{\circ}$ with respect to a horizontal line, taking the mean between the computations of Messrs. Lang and Scheffer. That the shadow-lines made an angle of 45° with the edges of the paper, could be understood on two different theories, viz., that their azimuth was $121\frac{1}{2}^{\circ}$ and 211° (N.E.). Mr. Bergsma declared that $211\frac{1}{2}$ was meant. Now, if we pass a plane through a shadow-line on the wall and its prolongation on the paper, this plane intersects the horizon along a line directed in an azimuth of $31\frac{1}{2}^{\circ}$ (N.E.), whereas the same plane has an inclination of $52\frac{1}{3}^{\circ}$ to the west. The normal on this plane meets the sky in a point having an azimuth of $121\frac{1}{2}^{\circ}$, and an altitude of $37\frac{1}{2}^{\circ}$. At the middle of totality the Sun had an azimuth of $131^{\circ}.4$, and an altitude of 54° . Accordingly there is a difference of 10° in azimuth and 16° in altitude. As regards the rough computation of the direction of the shadow-lines, this error may easily have been made, the more so as the observers were not prepared for an accurate observation of the phenomenon. Thus it appears, without anticipating more accurate observations on the occasion of late eclipses, that the shadow-lines were situated in planes perpendicular to the Sun’s rays. They moved from the Sun. Singularly enough, neither at Tjiléntap nor at the island Lawoengan, was anything of the phenomenon seen. At the island circumstances were very unfavourable, but at Tjiléntap the sky was clear.”

Photographs of the Total Solar Eclipse of December 1871.

When our last Report appeared, the excellent photographs taken by Colonel Tennant and Lord Lindsay’s photographic assistant, Mr. Davis, were not available for examination. Accordingly the Council refrained from expressing any opinion as to the bearing of the photographic results on the question of the nature of the coronal rays round the eclipsed Sun. It was pointed out that such an opinion could only be properly formed “when the reports of all the observers had been received, and when the valuable photographs of the Sun’s surroundings, obtained at the different stations, had been carefully examined and compared with each other.” This has now been done, and the result cannot but be regarded as most satisfactory. Mr. De La Rue, in his address to Section A. of the British Association, has ably summed up the bearing of these photographs on the questions which had been

at issue. "If the rays and rifts were really atmospheric," he remarks, "it would hardly be possible that they should present the same appearance at different stations along the line of totality; indeed they would probably change their appearance every moment, even at the same station. If they are cislunar, the same appearances could not be recorded at different stations. It is universally admitted that proof of the invariability of these markings, and especially of their identity as seen at widely-separated stations, would amount to a demonstration of their extra-terrestrial origin. Eye-sketches cannot be depended on: the drawings made by persons standing side by side differ often to an extent that is most perplexing. Now photographs have, undoubtedly, as yet failed to catch many of the faint markings and delicate details; but their testimony, as far as it goes, is unimpeachable. In 1870, Lord Lindsay at Santa Maria, Professor Winlock at Jerez, Mr. Brothers at Syracuse, obtained pictures, some of which, on account partly of the unsatisfactory state of the weather, could not compare with Mr. Brothers' picture obtained with an instrument of special construction;* but all show one deep rift especially, which seemed to cut down through both the outer and inner corona clear to the limb of the Moon. Even to the naked eye it was one of the most conspicuous features of the eclipse. Many other points of detail also come out identical in the Spanish and Sicilian pictures. None of the photographs of 1871, by Colonel Tennant and Lord Lindsay's photographic assistant, Mr. Davis, show so great an extension of the corona as is seen in Brothers' photograph, taken at Syracuse in 1870; but, on the other hand, the coronal features are perfectly defined on the several pictures, and the number of the photographs renders the value of the series singularly great. . . . We have in all the views the same extensive corona, with persistent rifts similarly situated. Moreover, there is additional evidence indicated by the motion of the Moon across the solar atmospheric appendages; proving, in a similar manner as in 1860 in reference to the protuberances, the solar origin of that part of the corona.

"The great problem of the solar origin of that portion of the corona which extends more than a million of miles beyond the body of the Sun has been set finally at rest, after having been the subject of a great amount of discussion for some years."

* On this point Mr. De La Rue remarks as follows:—"Mr. Brothers had, in 1870, the happy idea to employ a so-called rapid rectilinear photographic lens, made by Dallmeyer, of 4 inches aperture and 30 inches focal length, mounted equatorially and driven by clockwork; and he was followed in this matter by both Col. Tennant and Lord Lindsay in 1871. The focal image produced, however, is far too small ($\frac{3}{10}$ ths of an inch, about); therefore it will be desirable in future to prepare lenses of similar construction, but of longer focal length and corresponding aperture."

Polariscopic Observations of the Corona during the Total Solar Eclipse of December, 1871.

Mr. G. K. Winter, Telegraph Engineer on the Madras Railway, has described his polariscopic observations during the recent eclipse. He was with Mr. Pogson's party on behalf of the Madras Government. The instrument he used consisted of a small telescope of $2\frac{3}{4}$ inches in aperture and about 30 inches focal length, mounted equatorially. In front of the eye-piece was a polarimeter, consisting of four plates of thin glass mounted in a frame moveable on an axis at right angles to the direction of the bands in a Savart's polariscope, which was fixed in front of the frame; so that the rays from the object-glass passed first through the eye-piece, next through four plates of glass, and lastly through the Savart's polariscope to the eye.

"Although quite convinced myself," he proceeds, "of the fact of the radial polarisation of the corona, I was anxious this time to place it beyond doubt, by taking actual measurements of it in such a position that, if the polarised light proceeded from the unobscured portion of the Earth reflected from the atmosphere and again back to the eye, it could not be measured. I therefore chose the southern limb for my observations, and carefully got my bands radial to the Sun, and consequently making but a small angle to the horizon, before totality, keeping the field as nearly as I could in the same position-angle with respect to the Sun (by means of the right ascension tangent-rod) during totality. Immediately totality commenced, the white-centred bands appeared. I turned the axis of the frame with the glass plates until the bands disappeared. The angle the plates had to be turned through was 35° . I then turned the declination tangent-screw slightly, so as to get a portion of the corona a small distance from the limb (I think about $10'$) into the field. The plates had then to be turned through an angle of 45° before the bands disappeared. Three other measurements were taken in about the same position, the result showing that the polarization increased considerably with distance from the limb. It is evident that if the polarized light were really due to the reflection from the unobscured portion of the Earth, it would be polarized in a plane nearly at right-angles to the plane of my bands; and, consequently, its polarization could not be neutralised by the plates of glass in the position in which they were used. When the plates were inclined, so as to neutralise the corona polarization, I saw faint black-centred bands on the portion of the Moon's disk in the field. I did not observe any when the plates were at right-angles to the axis of the telescope, but I think I should have noticed them if they had existed; so that, although there was a sensible amount of light on the Moon's disk, sufficient to show bands when polarised by the glass plates, I do not think it was perceptibly polarised itself."

Observations made during the recent Annular Eclipse of the Sun.

It is long since any observations worthy of being specially recorded have been made during an annular eclipse of the Sun. But Mr. Norman Pogson, of the Madras Observatory, was successful during the annular eclipse of June 6 last, in recognising the reversal of the solar spectrum, a phenomenon which has hitherto only been witnessed during total solar eclipses. At the second contact, Mr. Pogson observed the solar spectrum reversed for a second or two. At the third contact, Mr. Pogson could recognise the reversed spectrum for six or seven seconds. This observation is of great importance, because, although during the eclipse of 1871 the phenomenon of the reversal of the spectrum—first observed by Young during the Mediterranean eclipse of 1870—was seen by several observers, yet others failed to recognise it. It is true that negative observations are of little weight in such a matter; but doubts existed, in consequence of the non-recognition of the phenomenon by some who might have been expected to see it if it existed. The observation of the reversal of the spectrum during an annular eclipse is decisive of the matter. The inference from the observation is that in the lower part (say the lower two or three hundred miles of the solar atmosphere), there exist the vapours of metallic and other elements.

Singular Phenomenon in the Solar Sierra.

M. Tacchini, the well-known Italian spectroscopist, has communicated to the Paris Academy a very remarkable observation, which is the more interesting as the period during which the observation was made includes the day of the annular solar eclipse observed successfully by Mr. Pogson. "I have just observed a phenomenon," he says, "which is altogether new in the whole series of my observations. From May 6th I had found certain regions in the Sun remarkable for the presence of magnesium. These regions were very extended, comprising arcs of from 12 to 168 degrees, whereas preceding observations gave no arcs larger than 66 degrees. At the meeting of the Society of Sciences of May 18 I presented a drawing of the entire solar border, executed on May 6, with indications relating to the position of the magnesium, adding special remarks upon the observations of the following days. Although the extension of the magnesium was everywhere considerable, I should notice the circumstance that the longest and most characteristic regions were found on the western border, as I had verified also in the case of the preceding observations (see *Le Bulletin de l'Observatoire*, 1871, No. 9). This sort of preference for the western limb is difficult to explain, and, consequently, it was interesting to continue the study of the rays of magnesium over the whole extent of the limb, which I continue to do each day when the atmosphere is pure and tranquil.

“ Lastly, on June 18, I was able to recognise the presence of magnesium round the entire limb; that is to say, the chromatosphere was completely invaded by the vapour of this metal. This general ebullition was accompanied by an absence of protuberances, which seems to me very natural; on the contrary, the flames of the chromatosphere were very marked and very brilliant. It seems to me as though I could see the surface of our great source of light renewing itself. The more marked and brilliant the flames were, the brighter and wider appeared the magnesium lines. At 288° very brilliant and characteristic flames were observed. I said to several persons present that a bright facula ought certainly to be seen at that point; and, as a matter of fact, observing the projected solar image, we found at the place indicated a very luminous facula, which was strictly on the limb of the Sun. It was a verification which I have often repeated, when alone, with results perfectly concordant. The granulations showed themselves very distinct, and on the contour of the disk the number of small faculæ was in perfect agreement with the presence of magnesium. In each position of the spectroscope I equally noted the relative intensity of the lines; and I observed, on a great number of occasions, that the variation in the width of the lines accorded perfectly with the variation of the luminous intensity of the chromatospheric flames observed at the place of the line C. The great abundance of magnesium still continues (June 18), though not round the whole limb. The observations of which I speak seem to me to demonstrate that we ought to admit that not local eruptions only take place, but also complete expulsions—that is to say, a mixture of certain metallic vapours with the chromatosphere—a mixture extending over the entire surface of the Sun, which, consequently, would appear to be still in a gaseous state. More than one person,” proceeds Tacchini, “has told me that the light of the Sun has not at present its ordinary aspect; and at the observatory we have judged that we might make the same remark. This modification should be attributed to magnesium.”

The Solar Prominences.

Father Secchi has published a *resumé* of his observations of these objects, tabulating the number, height, and width of the prominences observed in different solar latitudes during an entire year. He finds that there are two principal maxima of frequency, placed between 20° and 30° of north solar latitude, and between 10° and 30° of south solar latitude; and two secondary maxima, between 70° and 80° of latitude in each solar hemisphere. In successive rotations there is no trace of a progressive motion of the principal maxima towards the poles, as had been suspected. The prominences attain their greatest dimensions where they occur most frequently. Moreover, the regions richest in faculæ

coincide with the regions where the prominences have their greatest height and width. Among 893 prominences observed by Secchi, 471 were found to have a well-marked slope, resembling inclined planes. Of these, 370 were inclined in agreement with the law of movement of the solar atmosphere, and only 101 in the contrary direction; 40 (at the poles and equator) were vertical. Father Secchi is of opinion that these results cannot be accidental. He mentions that M. Spörer has arrived at the same result (later). He notices, also, that during the periods of greatest activity the law is more constant and decided. Among the most remarkable of Father Secchi's observations are those relating to the sierra:—"It is truly astonishing," he remarks, "to see this streak, adorned with fringes and hairs of the utmost delicacy, resting immovable in the middle of the disturbance agitating the edges of the Sun's limb. . . . These hairs, which seem to us so fine, are veritable flames on the Sun, and it is natural that our atmosphere should have no influence upon them."

Speaking of the theory of the material projection of matter from the Sun, Secchi suggests that the combination of motions due to projectile forces, with those produced by the circulation of the solar atmosphere, may serve to explain the curious curves in Lord Lindsay's photographs of the corona, as well as in the drawings of M. Liais and other observers.

Observations of the Bright Lines in the Spectrum of the Solar Atmosphere.

Prof. Young, who had already (as mentioned in our last Report) catalogued 103 lines in the spectrum of the solar atmosphere, has now succeeded in determining the places of no less than 273 lines. The instruments and methods of observation were those employed in the construction of the preliminary catalogue. The telescope 9 $\frac{4}{10}$ inches in aperture; spectroscope automatic, with dispersive force of 12 prisms. The great advantage possessed by Prof. Young on the present occasion lay in the elevation of the station (Mount Sherman), which is 8280 feet above the sea-level, the mean height of the barometer being 22.1 inches.

"The great altitude of the station," remarks Prof. Young, "(nearly 8300 feet,) and the consequent atmospheric conditions, were attended with even greater advantages for my special work than had been really expected, although I was never quite able to realise my *hope* of seeing all the Fraunhofer lines reversed, unless once or twice for a moment, during some unusual disturbances of the solar surface.

"Everything I saw, however, confirmed my belief that the origin of the dark lines is at the base of the chromosphere, and that the ability to see them all reversed at any moment depends merely upon instrumental power and atmospheric conditions.

“ In this view a catalogue of the bright lines actually observed is, of course, less important than it would be otherwise; still it is not without interest and scientific value, since the lines seen are naturally those which are really most conspicuous in the chromosphere spectrum; and this conspicuousness stands in important, but by no means obvious or even entirely simple, relations to the intensity of the corresponding dark lines, when such exist. There can be no doubt that a careful study of these bright lines and their behaviour would yield much valuable information as to the constitution and habitudes of the solar atmosphere.

“ In addition to the elements before demonstrated to exist in the chromosphere, the following seem to be pretty positively indicated—sulphur, cerium, and strontium; and the following, with a somewhat less degree of probability—zinc, erbium, and yttrium, lanthanum, and didymium. There are some coincidences, also, with the spectra of oxygen, nitrogen, and bromine, but not enough, considering the total number of lines in the spectra of these elements, or of a character, to warrant any conclusion. One line points to the presence of iridium or ruthenium, and only three are known in the whole spectrum of these metals.”

In many cases in the catalogue lines have associated with them the symbols of two or more elements. “ The coincidences,” remarks Prof. Young, “ are too many and too close to be all the result of accident. Two explanations suggest themselves: the first, which seems rather the most probable, is that the metals operated upon by the observer who mapped their spectra were not absolutely pure; either the iron contained traces of calcium and titanium, or *vice versâ*. If this supposition is excluded, then we seem to be driven to the conclusion that there is some such similarity between the molecules of the different metals as renders them susceptible of certain synchronous periods of vibrations—a resemblance, as regards the manner in which the molecules are built up out of the constituent atoms, sufficient to establish between them an important physical—and probably chemical—relationship.”

Connexion between Weather Changes and the Solar-Spot Period.

Mr. Baxendell has communicated to the Literary and Philosophical Society of Manchester two interesting papers on the relation between the solar-spot period and meteorological phenomena. In the first paper he considers the changes in the distribution of barometric pressure, temperature, and rainfall under different winds, during a solar-spot period. He shows that at Oxford changes take place in the relative amounts of rainfall

under different winds in a period corresponding with that of solar-spot frequency. Thus in the years when the number of groups of solar spots, as observed by Schwabe, was above the average, the amount of rainfall under west and south-west winds was greater than that under south and south-east winds; while in the years when the number of groups of solar spots was below the average the reverse of this took place, the amount of rainfall under west and south-west winds being less than that under south and south-east winds. The hypothesis which led to the investigation requires, however, that great diversity should exist in the relative amounts of rainfall under different winds at different stations. While at some the distribution will be similar to that at Oxford, at others it will be of an opposite, and in others again of an intermediate, character; but, whatever may be the nature of the distribution at any station, the changes to which it will be subject will take place in a period identical with the solar-spot period. In some localities the changes will be so slight or so irregular as not to be immediately referable to any well-defined law. These points on the surface of the Earth may be regarded as nodal points in the general system of circulation of the great currents of the atmosphere.

Among the places at which it seemed to him likely that the law of change in the relative amounts of rainfall under different winds would be found to differ considerably from that which prevails at Oxford, is St. Petersburg. He therefore considers, in the second paper, the amount of rain falling, under different winds, at St. Petersburg during the eleven years 1854-64. He finds that, regarding only the mean values for those years, there was a principal maximum of rainfall under west winds, and a secondary maximum under south-east winds, a principal minimum under east winds, and a secondary minimum under south winds. In the eleven years 1854-64, the number of groups of solar spots, as observed by Schwabe and others, was above the average in the five years 1858-62, and below the average in the remaining six years 1854-57 and 1863-64. Dividing the series of rainfall results into two corresponding series, and taking the means in the amounts under each wind, he finds that the mean amounts of rainfall under west, south-west, south, south-east, and east winds are greater in years of maximum solar-spot frequency than in years of minimum; while the amounts under north-east, north, and north-west winds, and calms, are less. Comparing, then, the total amounts which fell under west, south-west, south, south-east, and east winds in each year with those which fell under north-east, north, and north-west winds, and in calms, he finds the mean ratio to be 3.01, and the ratio for the years of maximum spot-frequency are all above this mean; while those for minimum years are all below it, with only one unimportant exception. He remarks that the close agreement which has thus been shown to exist at St. Petersburg between the times of maximum and minimum frequency of solar spots and those of the variations in

the distribution of rainfall under different winds gives increased value to the results derived from the Oxford observations, and affords additional support to the hypothesis he ventured to advance in a former paper,—that changes in solar activity, and consequently in the magnetic condition of the Earth, produce corresponding changes in the directions and velocities of the great currents of the atmosphere, and in the distribution of barometric pressure, temperature, and rainfall.

Telescopic Observations of Meteors.

Dr. Galle, of Breslau, has recently discussed the interesting question whether multiple meteors enter our atmosphere in flights, or owe their separation into discrete bodies to the effects of explosion. He remarks that several considerations seem to suggest the former theory, and quotes in its favour some telescopic observations recently made on meteoric bodies. Such observations are so seldom effected (simply because a telescope cannot be turned upon shooting stars, and the chances are enormously against the accidental passage of any of these bodies across the telescopic field of view), that great interest attaches to the few that have been recorded, especially when meteors have been seen with telescopes of considerable power. Two observations, both by Dr. Reimann, were recently announced, and the Königsberg heliometer was the instrument with which the observations were made. In the first case, three small meteors separated from each other by small dark spaces were seen to travel together across the telescopic field. The two in front were smaller than the third, and the three presented the appearance of a small isosceles triangle, whose base travelled in front—thus, $\cdot \vdots$. These bodies moved so slowly that they could be conveniently watched. This slow motion implies great distance, yet they were as bright as stars of the fourth magnitude. The observer formed no estimate of their apparent dimensions. The bodies showed no trains. In the second case, a small meteor passed across the field of view, in whose track, at a distance of about a quarter of a degree, followed a fainter meteor.

Dr. Galle remarks, that the number of such observations is not large. Most of those made before the year 1860 are collected in a communication from Haidinger, read before the meeting of the Vienna Academy in February 1861, and relating to the double meteor of Elmira and Long Island. Galle considers that if telescopic observations could be oftener effected, the number of cases of multiple meteors could be largely increased. One of the most striking instances of a multiple meteor was the one observed by Schmidt at Athens, October 18, 1863. In that case, the naked eye could recognise only what appeared to be a single meteor, but in the telescope two large meteors could be seen travelling in front of a number of small fireballs, each of which was

followed by a train. The well-known skill and accuracy of Schmidt and the length of time (14 seconds) during which the object continued in the telescopic field, render this observation peculiarly valuable.

Dr. Galle considers that his researches into the phenomena presented by the meteors which fell at Pultusk on January 30, 1868, as a rain of stones, demonstrate that the meteors were separate long before they reached the place of so-called explosion, and that this place is only the spot where a complete resistance to the planetary velocity and a partial rebound from the impressed air take place, and whence the meteor falls with a velocity corresponding to the law of terrestrial gravity. Haidinger, from certain physical features of fallen meteors, had already inferred the necessity of the theory that the separate meteors had followed distinct paths through the air. Dr. Galle considers that at present it may be regarded as still an open question, whether meteorites enter our atmosphere, from outer space, already separated so as to form a swarm, or whether, shortly after entering and during their passage through the air, they are reduced through the effects of heat into smaller fragments, which the more or less freshly broken appearance of many fragments, as distinguished from the full or partial over-crusting of others, seems to indicate.

He notes as unusual, in the first observation by Dr. Reimann, the circumstance that the two meteors travelling in front were smaller than the one which followed them.

Progress of Meteoric Astronomy in 1872-73.

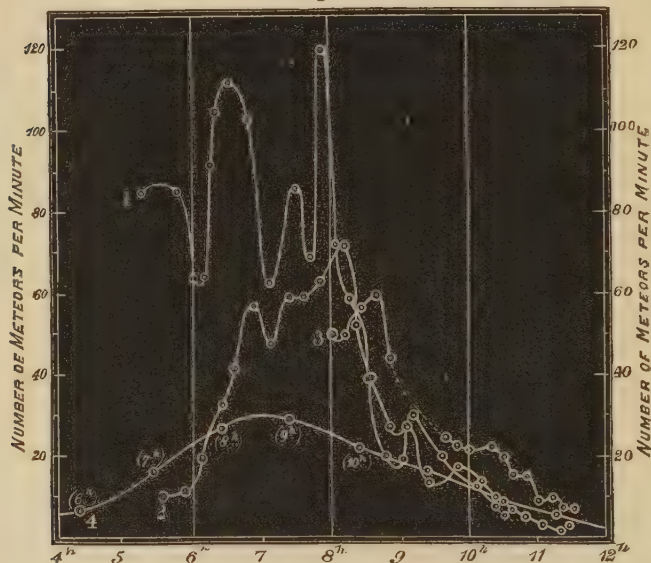
The newly trodden field of meteoric astronomy relating to the observations of aërolites, shooting-stars, and meteor-showers, and to the discovery of the connexion of the latter with periodic comets, for which the gold medal of the Society was last year awarded to Professor Schiaparelli, has, during the past year, presented some important discoveries, and contributions to our knowledge of meteoric systems. Comparing the present views of meteor-showers with those which were entertained until shortly before the appearance of the November shower in 1866, the progress of observation and of inquiry has indeed surpassed expectation. The orbits of shooting-stars were shown before that time to resemble those of comets, and suspicions of their identity were entertained, when (as observed by Professor Schiaparelli in a recent communication to Mr. Greg) Nature appeared to use her utmost efforts to impress upon her adherents the correctness of this suspicion by a combination of the most singular coincidences. The star-showers of August 1863, of November 14th, 1866-67, and of November 27th, 1872, together with the Comets 1861, I.; 1862, III., and 1866, I.; and the dismemberment of Biela's Comet, have all been observed within the past few years, when an

exact idea of the astronomical connexion probably subsisting between these bodies was beginning to be entertained, and the proofs supplied by these several examples were accordingly most urgently required. Among the last-mentioned comets the third comet of 1862 was first shown by Schiaparelli, in 1866, to be identical in its orbit with the path of the August meteor stream. Within a few weeks of this announcement the first comet of 1866 was almost simultaneously recognised by Peters, Schiaparelli, and Oppolzer, as moving in the same path as the Leonids, or meteors of the 14th of November in that year. About a month from the last of these discoveries it was remarked independently by Weiss and Galle that the orbit of the first comet of 1861 coincides in its position with that of the meteor stream producing the well-known star-showers of the 20th of April; and at the same time, Weiss, D'Arrest, and Galle, independently pointed out with every favourable circumstance of probability that the comet of Biela, expected in vain by astronomers to have made its appearance in the previous year, was connected with certain meteor-showers observed in late years in the end of November and beginning of December.* The probable return of such a meteor-shower was predicted by D'Arrest during the first days of December 1878; by Galle on the night of the 27th of November, in any coming year; and by Weiss towards the same time, or the beginning of December in years of the nearest approach of Biela's Comet to the Earth. The latter predictions were most nearly verified by Professor Schiaparelli, in the same year, who discovered, among the observations of Signor Zezioli, at Bergamo, on the 30th of November, 1867, a distinct, although not copious star-shower, which he did not hesitate to recognise as forming part of the meteor stream of Biela's Comet. Another cycle of the comet's revolutions having afterwards elapsed, the attention of observers was again called to this meteoric shower in a note by Professor Herschel, in the *Monthly Notices* of last year (Supplementary Number), requesting their watch for its occurrence during the comet's present perihelion passage. The shower was abundantly observed on the night of the 27th of November last, agreeing with the date assigned to it by Dr. Galle; and, although far inferior in brilliancy, it yet scarcely fell short (according to the descriptions of some of the observers), in the frequency of its meteors, of the great showers of November 14th, 1866-67. Particulars of its appearance at the principal observatories in Europe and America, and from many private sources, were contributed to the scientific journals of the countries in which it was most favourably

* *Astronomische Nachrichten*, No. 1632; Weiss, on Orbits of Comets and Meteor-showers (concluded in No. 1710).—No. 1633; D'Arrest, on Meteor-showers apparently connected with Biela's Comet (a list of these meteor-showers is enumerated by D'Arrest, nearly identical with that in the Supplementary Number of the last volume of the *Monthly Notices*).—No. 1635; Galle, on the Association of a Comet with the April Star-showers, and of Periodic Meteors in November with Biela's Comet.

observed.* The accompanying diagram (fig. 1) presents the average frequency per minute of the meteors seen by Dr. Schmidt at Athens, by Mr. Lowe and Professor Grant in England and Scotland, and by two assistants of Lord Rosse in Ireland, reduced to the same epochs of Greenwich time. A second diagram (fig. 2) exhibits all the observed positions of the radiant point of this shower hitherto collected by Professor Herschel, a detailed description of which will be communicated to the Society at a future Meeting. The shower was not seen at the Royal Observatory, Greenwich, nor generally in the southern part of England,

Fig. 1.



Numbers of Meteors seen per minute in the Star-shower of Nov. 27, 1872, by one observer; (1) Mr. Lowe (Nottingham); (2) Prof. Grant (Glasgow); (3) Lord Rosse (observers in Ireland, in Greenwich time); (4) Dr. J. F. Schmidt (Athens, hourly numbers for one observer, at each hour of Athens time, reduced to numbers per minute and to Greenwich time).

the sky being completely overcast; and, owing to the early hour of its appearance in Europe, it was only partially visible in America. Accounts from the Mauritius announce it to have been well seen there, and views of its occurrence in the East, already received, appear to have been occasionally obtained.

Among the many astronomical observers who recognised in the return of this shower a passage of the Earth through the

* *Comptes Rendus*, December 2, *et seq.*, Heis, *Wochenschrift für Astronomie*, December 11, *et seq.*, these *Notices*, December 13, 1872, *et seq.*, *American Journal of Science*, January, 1873. Memoirs on the appearance of the shower in their own countries were also published by Drs. Littrow and Wolf, and by Signor F. Denza.

track of Biela's Comet, Professor G. Forbes, of the Andersonian University of Glasgow, wrote to Professor Herschel, on the 20th of December, "Had any one the good sense to look out, on the morning of the 28th of November, for a certain nebulous mass, that was probably visible in a comet-seeker in the position R.A. $13^h 35^m$, S. Decl. 46° ; i.e. at the opposite point to the radiant?" The point indicated by Professor Forbes is in the southern hemisphere, in the constellation of the *Centaur*, and only visible to observers in low, or southern latitudes. A telegram to this purpose was actually received on the night of the 30th of November by Mr. Pogson at Madras from Professor Klinkerfues.

Fig. 2.

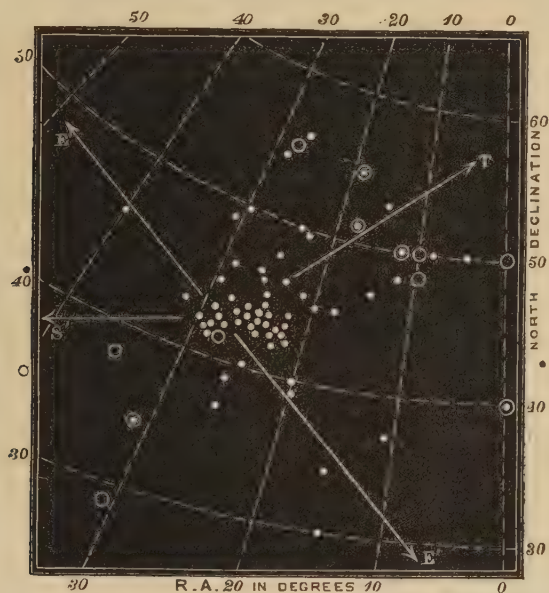


Chart of 72 Positions of the Radiant-point observed on the 27th of Nov. 1872; showing the directions of lines drawn to S', the antisolar point; E, E', the apex and antiapex of the Earth's way; and T, transverse to this direction.

N.B.—In this figure the simple dots represent the positions most accurately observed; the simple circles are positions described only by the constellations; and the dotted circles are places of the Radiant Point described more approximately by their neighbourhood to, or general alignment with, particular fixed stars.

of Göttingen; and in the search which it recommended, Mr. Pogson was fortunate in discovering the missing comet, on the 2nd of December, within fifteen degrees of the place indicated by his instructions. On the night of the 3rd it was found at a point more than three degrees from its former place, apparently retrograding along a path almost parallel to, but several degrees dis-

tant from that in which the meteor stream must, at the same time, have been apparently traversing the sky. Unless the observations refer to separate individuals of the cometary pair, it is difficult to extract from them the actual position relatively to the Earth which the double comet of Biela occupied during the progress of the meteor-shower, but that it was in very close proximity to the Earth appears to be at least highly probable from the twice-recorded places of the cometary body discovered by Mr. Pogson.

The first general list of radiant-points of shooting-stars for the whole year was that published in 1849 by Dr. Heis, of Münster, from the results of ten years' observations of shooting-stars at Aix-la-Chapelle; a more complete list, including observations at Münster until 1861, appeared in the *Astronomische Nachrichten*, and in the *Monthly Notices* of the Astronomical Society for May 1864. The next, and most complete list of the same kind, published by Dr. Heis, was communicated to the *Astronomische Nachrichten* in April 1867. The radiant-points in these lists were almost entirely confined to the northern hemisphere. In the latter year a list of thirty-five radiant-points in the southern hemisphere was obtained by Dr. Heis from the observations of Dr. Neumayer at Melbourne, and was included by Dr. Neumayer in the discussion of his meteorological observations at the Flagstaff Observatory from 1858-63. In the same years as the latter lists published by Dr. Heis, Mr. R. P. Greg obtained from the observations printed in the Annual Reports of the British Association, a series of radiant-points for the northern hemisphere corresponding in many instances so nearly with those of Dr. Heis, that the nomenclature adopted in Dr. Heis' lists was, with a few alterations, principally affecting the dates of appearance of the meteor-showers, for the most part adhered to. Dr. Schmidt, of Athens, whose exact observations and discussions of the appearances of shooting-stars are among the earliest and most continuous recent records of these phenomena, also lately contributed a list of radiant-points for the northern hemisphere, in the *Astronomische Nachrichten* for 1869,* similar to those of Dr. Heis, and arranged from the long series of his observations for the different months of the year. Since his important discovery of the connexion of meteor-showers with periodic comets, Professor Schiaparelli has endeavoured to collect a sufficient number of observations of shooting-stars on all nights of the year, to be able to determine their special radiant-points on every night; and in this object, partly by the indefatigable exertions of one observer, Signor Zezioli of Bergamo, whose observations extended with little variation for all months of the year and for all hours of the night from April 1867 until the end of the year 1870, and partly by the concurrence of the Italian astronomers, whose combined watch

* *Astronomische Nachrichten*, No. 1756, abstracted from a larger work on his observations of shooting-stars in the second volume of the *Publications de l'Observatoire d'Athènes*.

is annually organised by Signor F. Denza, in Piedmont,* Professor Schiaparelli has met with eminent success. Employing only the observations made by Zezioli during the years 1868-70, a list of 189 radiant-points in the northern hemisphere exhibits his present results from their discussion,† to forty-five of which‡ notes representing their resemblance to meteor-showers, already identified in previous catalogues, are appended, and descriptions are added in other cases where hitherto unrecorded meteor-showers had been observed. In this preliminary list the following examples are pointed out (see the Table at p. 260) in which the orbits of certain meteor-streams are recognised either by himself, or by Dr. Weiss, as having more or less certain resemblances to known orbits of periodic comets. A few additional cases at the end of the list, extracted from Dr. Weiss' latest Memoir, are found to occur in Heis' and Neumayer's list of radiant-points for the southern hemisphere.

Besides the four well-defined agreements noted at the beginning of this Report, it will be seen that comparatively few of the many radiant-points of shooting-stars hitherto observed are capable of being possibly identified with the orbits of known comets from which they may have been derived. Although for this purpose the greatest precision in determining the exact date or duration, as well as the radiant position, of a meteor-shower, is evidently desirable, the comparative table by Mr. Greg, contained in the last volume of the *Monthly Notices*, presents many instances of radiant-points, not far apart in their positions, occupying nearly the same region of the heavens for several successive weeks, and similar concourses of the separate radiant-points of his list, are noticed by Professor Schiaparelli, in the months of January (for two or three weeks, in *Boötes* and *Ursa Major*), in the beginning of April (for eight days, near ϵ and σ *Herculis*, in the latter part of July (for fifteen days, near γ *Cygni*), and from the 3rd to the 12th of August around the well-known radiant-point in *Perseus*, some at least of which are not improbably the scattered reproductions of originally more compact meteor-showers. Whether the small number of meteor-streams hitherto found to be identifiable with known comets will be largely increased by the attention now generally excited to their connexion will be an interesting sequel to be expected from the gradual perfection, and verifications which continued observations will, perhaps, principally contribute towards the present lists. Among the most abundant observations available for this purpose during the past year, are those of the annually recurring showers of January, April, August, October, November, and December, continued whenever a favourable view of the stars could be obtained by Mr. Glaisher, at the

* *Norme per le Osservazioni delle Meteore Luminosi nel 1870-1, 1871-2, and 1872-3*; by F. Denza. Pamphlets in 12mo; Turin, 1870-71-72.

+ Von Boguslawski's Translation of Schiaparelli's Work on the *Astronomical Theory of Shooting-Stars*, p. 84, *et seq.* Stettin, 1871.

‡ *Reports of the British Association*, volume for 1870, p. 98.

Royal Observatory, Greenwich, and by the Rev. Mr. Main, at Oxford. Many meteor tracks recorded on those dates, and at other times of the year, are described in the latest published volumes of the Annual Observations of those Observatories.* The results of observations at Stonyhurst, by the Rev. S. J. Perry, and at many other stations made for the British Association on the last-mentioned periodic nights, were also communicated during the past year to Professor A. S. Herschel,† with general descriptions of those showers, of which abstracts are contained in the last volume of the Reports of the British Association, showing evident indications of their extraordinary recurrences on each of the periodic dates. Similar observations of the August and November star-showers in 1872, with similar results, were collected last year (as in previous years) by a Committee of the French Scientific Association under M. Leverrier's directions, and in Italy under the directions of P. F. Denza, of the Moncalieri Observatory, near Turin. A considerable shower of the Leonids was noted at Matera, in Italy, between 3^h and 6^h A.M. on the morning of the 14th of November last, the number seen greatly exceeding that noted in the same watch during the three hours after midnight, immediately preceding its display, and leaving no doubt of the return of the shower with some abundance on the annual date. Owing apparently to the brightness of the moonlight, and to the generally cloudy state of the sky at other places, where it was expected, this definite return of the shower appears to have escaped all further observations. Among the aërolites recently reported to have fallen, at Searsmont, Maine (U.S.), on the 21st of May, 1871, at Montéreau, France, in November 1871, and at Lance St. Amand and Pont Loisel, in France, on the 23rd of July, 1872, the two last were meteorites of large size, and the last afforded an example of division in its flight, two fragments of it being found at a distance of more than seven miles apart.‡ It was preceded on the evening before its occurrence by a remarkably bright fire-ball seen at many places in the south of England, before twilight had disappeared, on the 22nd of July. An interesting occurrence of another recent aërolite, which fell in Germany in June 1870, and which was lately brought to Dr. Heis, is related by him, and the unusual composition of the meteorite is fully described by Dr. G. vom Rath in the number for July last of Poggendorf's *Annalen der Physik*.

An interesting speculation by Professor Schiaparelli on the hyperbolic velocities of some recently observed aërolites and fire-balls,§ occurs in his last published work on the *Astronomical*

* *Greenwich Magnetical and Meteorological Observations*, vols. for 1870 and 1871; *Observations of Shooting-Stars made at the Radcliffe Observatory, Oxford* (chiefly by Mr. Lucas), in the years 1869, 1870, and 1871; Volume of the *Radcliffe Observations* for 1869.

+ *British Association Reports*, vol. for 1872.

‡ See M. Daubrée's description of this Stonefall in the numbers of *Comptes Rendus*, for August 5 and August 12, 1872.

§ Six instances of aërolitic fireballs of which hyperbolic velocities were

Theory of Meteors, relating to the question of the possible identity, or of the separate origin of these meteors, and of ordinary shooting-stars or meteor-showers. Rejecting, on apparently sufficient grounds, as fallacious, the conclusion of Laplace, that if comets, before entering the sphere of the Sun's attraction, are supposed to be traversing space with various velocities in various directions, the probability of their attaining the immediate neighbourhood of the Sun in parabolic orbits is many thousand times greater than the probability of comets with hyperbolic orbits approaching it so closely as to become visible from the Earth; and adopting the exactly opposite conclusion that the frequent occurrence of parabolas, and the entire absence of hyperbolas of any very great excentricity among the orbits of non-recurrent comets indicates them all to be originally journeying in space with nearly the same velocity, and in nearly the same direction as the Sun, Professor Schiaparelli regards these bodies as the original inmates, or portions of one of the "star-drifts," of whose existence very decided proofs have lately been obtained by Mr. Proctor; and as composing, with other stars of the same vast eddy, attendant bodies accompanying in its journey through space the general "drift" or star-family, of which the Sun itself forms a part. On this assumption, aërolites and meteors moving with hyperbolic velocities are bodies from more distant spaces than the star-family of the Sun, or wanderers from the regions of more distant star-drifts, whence they have, possibly, been projected, with sufficient initial velocities to escape from their spheres of attraction by the stars themselves; and their origin is, in this case, entirely different from that of comets, and of meteoric showers. If, as Professor Schiaparelli observes, this be the real explanation of the high velocities occasionally met with among the best recorded descriptions of aërolites and fire-balls, the evidence already obtained by the spectroscope of a general unity of composition among the remotest fixed stars is even more remarkably extended by the analysis of meteorites to the utmost limits of the starry sphere. But if the innumerable crowd and weight of the stellar fragments which this hypothesis supposes should appear to offer an insurmountable objection to its reception, the only obvious alternative remaining open to conjecture is to regard the occasionally observed high velocities of aërolites, or fire-balls, as constituting very rare exceptions; and the generality of both aërolites and shooting-stars to be moving in orbits, like the comets, with velocities which seldom greatly surpass the speed communicated to them by the Sun's attraction, and as falling towards it from spaces not more distant than those of the parent eddy, or "star-stream," whose drift, or motion of translation in space, is found to be in general nearly similar to the proper motion of the Sun.

credibly computed, are cited by Schiaparelli in his above-quoted work (Translated from the Italian by Dr. von Boguslawski), *Entwurf einer Astronomischen Theorie der Sternschnuppen*, p. 207, *et seq.*

A List of Meteor-Showers resembling in their Computed Orbits the Orbits of Certain Comets.

Reference No. in
list of Schiaparelli and
Boguslawski.

Similar Radiant Points contained in
other Lists.

Date of Meteor-Shower.	Position of Radiant-Point. R.A. N. Decl.	Date of Meteor-Shower.	Position of Radiant-Point. R.A. N. Decl.	Name of Radiant-Point and Authority.	Supposed Derivative Comet.	Date of Passage through Node.	Position of Cometary Radiant Point.	Authority and General Remarks.
5 Jan. 11-12	183° + 28°	Jan. 1-25	183° + 36°	M G ₁ (G & H)	1792, II. 88	Jan. 5	193° 8' + 24° 6'	Weiss. Not confirmed by Schiaparelli's radiant-point.
23 Jan. 31	134 + 40	Jan. 16—Feb. 1	169 + 45	M ₂ (Heis)	1680, 88	Dec. 26	132° 0' + 21° 4'	{ Weiss. Not confirmed by Schiaparelli's radiant-point.
		Jan. 1—Feb. 9	135 + 40	M _{1,2} (G & H)	1854, IV. 88	Feb. 13	304° 0' + 37° 3'	{ (Weiss.) No earlier observation of a similar radiant-point (near γ Cygni), in other lists. A.S.H.
54 Apr. 13	231 + 27	Mar. 15—Apr. 20	305 + 27	W Z (G & H)	1847, I. 88	Apr. 11	Meteors' Comet's perih. dist. 0° 65'.	{ A good resemblance, excepting in the perihelion distance; Schiaparelli. See Nos. 135, 143.
63 Apr. 25	260 + 24	Mar. 12—Apr. 30	223 + 40	M G ₂ (G & H)	1862, IV. 88	Mar. 16	249° 4' + 1° 0'	{ (Weiss.) A. S. Herschel. +
		Mar. 3-25	247 — 3	S Z ₁ (G & H)	1748, II. 88	Apr. 23		{ Good accordance of the orbits. Observations somewhat rough. Schiaparelli.
118 July 28	174 + 55	Mar. 15? Apr. 23	268 + 25	Q H ₁ (G & H)	1850, I. 88	June 24	312° 4' 60° 6'	{ (Weiss.) A. S. Herschel. +
		June 11—July 11	315 + 60	B ₁ (G & H)	1737, II. 88	July 27	175° 2' + 70° 9'	{ Weiss; Schmidt; Schiaparelli. A good agreement, excepting in inclination of meteor-orbit = 27°; of Comet = 39° 3'.
140 Aug. 10	47 + 18	July 29—Sep. 6 End of July	172 + 60 165 + 62	V (G & H) No. 22 (Schm)	1862, II. 88	Aug. 19	47° 5' + 13° 0'	{ (Weiss.) Radiant precise, at Earth's Apex. Agreement with the comet rather doubtful? Schiaparelli.
135 Aug. 5	315 + 80	July 28—Sep. 10	+ 90	N _{12,13} (G & H)	1853, III. 88	Aug. 12	298° 9' 80° 2'	{ Approximate agreement, excepting in perihelion distance of comet = 0° 3'; of meteors = 1° 0'.
143 Aug. 11	+ 90	Aug. 1-15	345 + 85	N ₁₃ (Heis)	1840, I. 88	Jan. 20	128° 4' — 28° 6'	{ Radiant is that of a cometary stream with a proper perihel. distance. Weiss and Schiaparelli. See above, No. 54.
		Aug. 16-31	295 + 79	N ₁₄ (Heis)	1092, 88	Feb. 5	103° 2' — 34° 4'	{
		January	105 — 27°	I ₂ (H & N)	1683, 88	Mar. 16	206° 9' — 48° 4'	{
		February	105 — 45°	I ₃ (H & N)	1779, 88	Oct. 19	39° 2' — 29° 7'	{
		March	192 — 38°	H ₁ (H & N)				{
		October	10 — 35°	X ₁ (H & N)				{

* The Comparative Table by Mr. Greg. in the R.A.S. Monthly Notices of last year (vol. xxii p. 218), and the latest list of Prof. Heis in the *Astronomische*

*Papers read before the Society from February 1872, to
February 1873.*

1872.

- Mar. 8. Source of Solar Heat. Mr. Hall.
Aurora of February 4, 1872. Mr. Finlayson.
Nébuleuses découvertes et observées à Marseille. M. Stéphan.
Observations de la Planète (117) *Lomia*. M. Stéphan.
Summary of Sun-spot Observations during 1871.
Messrs. De La Rue, Stewart, and Loewy.
On the Nebula surrounding α *Argús*. Mr. Russell.
Total Solar Eclipse, Dec. 1871. Mr. Russell.
Longitude of Teheran. Col. Walker.
On the use of two Eyes in detecting the Motion of the Clouds, &c. Mr. Percival.
Measures of Binary Star ξ *Ursæ Majoris*. Mr. Knott.
On a pair of Differential Equations in the Lunar Theory. Prof. Cayley.
On the Variations of the Positions of the Orbit in the Planetary Theory. Prof. Cayley.
On Uniformity in the Measurement of Position Angles with the Telescope. Capt. Noble.
On an unsuspected Cause of Diffraction Phenomena in a Telescope. Capt. Noble.
On an Automatic Spectroscope. Mr. Browning.
Russian Preparations for Observation of Transit of *Venus*. M. O. Struve.
Note on Colour as affected by Variation of Optical Power. Col. Strange.
On a Double Image Micrometer. Mr. Browning.
On a Telespectroscope for Solar Observations. Mr. Browning.
Apr. 12. Solar Eclipse, Dec. 12, 1871. Mr. Tebbutt.
On the Proposition 38 of the 3d Book of Newton's *Principia*. Mr. Todhunter.
Second Part of a Memoir on the Development of the Disturbing Function in the Lunar and Planetary Theories. Prof. Cayley.
Observations des Petites Planètes *Peitho* (118) et *Egine* (91), et Nébuleuses Nouvelles découvertes par lui, &c. M. Borelly.
On the Law of Facility of Errors of Observation and on the Method of Least Squares. Mr. J. W. L. Glaisher.
Discovery of Minor Planets (118), (119), (120). Mr. Dunkin.

- On the Insufficiency of existing National Observatories.
Col. Strange.
- Observations of Encke's Comet. Mr. Hind.
- Orbit of Binary Star Σ 1938 near μ^2 Boötis. Mr. Hind.
- May 10. On the Nutoscope, an Instrument for showing Precession. M. Zenger.
- On Tables of *Jupiter's* Satellites. Mr. Maguire.
- On Astronomical Units. Mr. De Crespigny.
- Eclipse of *Jupiter's* Satellites, April 11, 1872. Capt. Noble.
- Occultations of Stars by Moon. Capt. Noble.
- On an Altazimuth Mounting for a Telescope. Mr. Brett.
- On Errors in Vlacq's Table of 10-figure Logarithms of Numbers. Mr. J. W. L. Glaisher.
- Observations of Planet (120). Dr. C. H. F. Peters.
- Elements of Minor Planet (119). M. Péchule.
- On the Discovery of *Saturn's* Second Satellite. Mr. Proctor.
- On the Densities of *Jupiter's* Satellites. Mr. Proctor.
- On the Value of the Stereoscope as applied to the Examination of Eclipse Photographs. Mr. Ranyard.
- June 14. Aurora of Feb. 4, 1872. Rev. J. Slatter.
- On the Tides in *Mars*. Mr. De Crespigny.
- On Future Solar Eclipses. Rev. S. J. Johnson.
- Additions to Paper No. 2094. Mr. J. W. L. Glaisher.
- Occultations of Stars by Moon, and Phenomena of *Jupiter's* Satellites. Rev. R. Main.
- New Tables of *Uranus*. Mr. Newcomb.
- Discovery of Planet (121). Mr. Watson.
- Observations of Planet *Venus*. Mr. Langdon.
- On Radiant Points of Meteors. Mr. Greg.
- Eclipse Photography. Mr. Brothers.
- On the Orbit of *Castor*. Mr. Wilson.
- Improvements in Tripod Stands. Mr. Lecky.
- The Rich Nebular Regions in *Virgo* and *Coma Berenices*. Mr. Proctor.
- On the Desirability of Watching for the November Meteors in this year. Mr. Proctor.
- Comparison of Photographic Pictures of the Corona taken in 1869-70-71. Mr. Ranyard.
- On Photographic Irradiation in over-exposed plates. Lord Lindsay.
- Observations of the Zodiacal Light at Palermo. Prof. C. P. Smyth.
- On some Observations of *Jupiter*, 1871-72. Mr. Browning.
- On certain Phenomena surrounding the Limb of the Sun in the Telescope. Mr. Brett.

- Nov. 8. The Coloured Cluster round α *Crucis*. Mr. Russell.
 On the Diffraction of Object-Glasses. Hon. J. Strutt.
 On a Volcanic Appearance in the Sun. M. Chacornac.
 Graphic Conversion of Stellar Co-ordinates. Rev. A. Freeman.
 On Changes in Nebula surrounding η *Argús*. Mr. Abbott.
 On the Arc of Meridian measured in South Africa. Mr. Todhunter.
 Future Solar Eclipses. Mr. Maguire.
 On a proposed Double Altazimuth. Mr. Carrington.
 On the Rate of a Clock going in a partial Vacuum. Mr. Carrington.
 On a modified Form of Solar Eye-piece. Mr. Browning.
 On an Observing Chair for a Newtonian Telescope. Mr. Browning.
 On Lord Lindsay's Preparations for Observation of the Transit of *Venus*, 1874. Lord Lindsay and Mr. Gill.
 Mean Places of 78 Stars near South Pole. Mr. Stone.
 On the Parallax and Proper Motion of *Lalande 21185*. Mr. Lynn.
 On the Examination of the Photographs taken during the Total Eclipse of Dec. 11-12, 1871. Col. Tennant.
 Observations of the Zodiacal Light. Mr. Fasel.
 On the Origin of the November Meteors. Mr. Proctor.
 List of Co-ordinates of Stars within and near the Milky Way. Mr. Marth.
 On the probable early Appearance of the Comet of the November Meteors. Mr. Hind.
 Ephemeris of the Angle of Position and Distance of the Binary Star α *Centauri*. Mr. Hind.
 Note on the first Comet of 1818. Mr. Hind.
 Note on the Binary Star α *Geminorum*. Mr. Hind.
- Dec. 13. Observations of Solar Prominences. Capt. Tupman.
 Colours and Magnitudes of Southern Stars. Capt. Tupman.
 Markings on *Uranus*. Mr. Buffham.
 Meteor Shower of Nov. 27, 1872. Lord Rosse.
 Ditto ditto Mr. Lowe.
 Ditto ditto Prof. Grant.
 Ditto ditto Rev. S. J. Perry.
 Ditto ditto Mr. Fasel.
 Ditto ditto M. Denza.
 Ditto ditto Mr. Wilson.
 On the Radiant Point of ditto. Mr. Hind.
 On the Colours of the Components of γ *Delphini*. Mr. Elger.
 On the Proper Motion of *Lalande 21258* and *Groombridge 1830*. Mr. Lynn.

- Note accompanying Charts showing the Proper Motions of all the Stars in the Catalogues of Proper Motions by the Rev. R. Main and Mr. Stone. Mr. Proctor.
- Note on Star Guaging. Mr. Proctor.
- A Minimum Estimate of the Height of the Corona of Dec. 11, 1871. Mr. Ranyard.
- On the Progress to Accuracy of Logarithmic Tables. Mr. J. W. L. Glaisher.
- Meteoric Shower of Nov. 27. Prof. A. Herschel.
- Ditto ditto Miss Readhouse.
- On the Solar Corona. Mr. Brett.
- Elements of the Orbit of ξ *Ursæ Majoris*. Mr. Hind.
- On the circumstances of the Transit of *Venus*, 1874, Dec. 8, at Port Louis, Mauritius. Mr. Hind.
1873. Jan. 10. Meteoric Shower, Nov. 27, 1872. Mr. Denning.
- Ditto ditto Comm. Wharton.
- Elements of Minor Planet (118) *Peitho*. M. Oppolzer.
- On Mr. Carrington's Note on the Rate of a Clock going in a partial vacuum. Rev. Dr. Robinson.
- On the Re-discovery of Biela's Comet. M. Klinkerfues.
- Meteoric Shower of Nov. 27. Capt. Gray.
- On Evidence of Internal Motion in the Meteor Swarm of Nov. 27, 1872. Mr. Burton.
- On an Apparatus for connecting the Hour Circle of the Equatoreal with the Regulator, and rendering audible the beats thereof. Mr. Erck.
- Ephemeris for Physical Observations of the Moon. Mr. Marth.
- Catalogue of Double Stars. Mr. Burnham.
- On an observed discordance between the Readings for Zenith Point of the Transit Circle, Cape of Good Hope. Mr. Stone.
- Note on Charts illustrating the presentation of *Mars* during the year 1873, and showing the Martial Lands and Seas which will be in view at different epochs. Mr. Proctor.
- Apparent Paths of 51 Shooting Stars. Prof. A. S. Herschel.
- On a Compensation for the Barometric Error of Clocks. Mr. Denison.
- Observations of Occultations of Stars by the Moon, and Phenomena of *Jupiter's* Satellites. Sir G. B. Airy.
- On the Re-discovery of Biela's Comet. Capt. Tupman.
- On an Error in the R.A. of Groombridge 3735. Mr. Dunkin.
- Summary of Sun-spot Observations at Kew. Mr. De La Rue.
- Observations of Shooting Stars. Capt. Tupman.
- Note on the Total Solar Eclipse of 2151. Mr. Hind.

List of Public Institutions and of Persons who have contributed to the Society's Library, &c. since the last Anniversary.

Her Majesty's Government.
 Her Majesty's Government in Australia.
 Her Majesty's Secretary of State for India.
 The Lords Commissioners of the Admiralty.
 Royal Society of London.
 Royal Society of Edinburgh.
 Royal Asiatic Society.
 Royal Asiatic Society of Bengal.
 Royal Dublin Society.
 Royal Geographical Society.
 Royal Institution.
 Royal United Service Institution.
 Royal Society, Tasmania.
 Geological Society.
 Photographic Society.
 Zoological Society.
 Society of Arts.
 British Meteorological Society.
 British Association.
 The Bodleian Library.
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 British Horological Institute.
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 Observatory, Bergen.
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Observatory, Prague.
Observatory, Collegio Romano.
Observatory, Palermo.
Observatory, Leyden.
Observatory, San Fernando.
Observatory, Sydney.
Observatory, Zurich.
United States Naval Observatory.
The Dudley Observatory.
Italian Eclipse Committee.
Italian Spectroscopic Society.
L'Académie des Sciences de l'Institut de France.
Dépôt Général de la Marine.
Imperial Academy of Sciences, Vienna.
Imperial Academy of Sciences, St. Petersburg.
Imperial Academy of Sciences, Berlin.
Royal Academy of Sciences, Göttingen.
Royal Academy of Sciences, Munich.
Royal Academy of Sciences, Brussels.
Royal Academy of Sciences, Turin.
Royal Society of Sciences, Naples.
Hungarian Academy of Sciences, Kasan.
Royal Academy of Sciences, Amsterdam.
The Academy de Lincée.
Royal Institute of Lombardy.
Istituto Tecnico, Palermo.
Royal Society, Copenhagen.
Royal Society, Leipsig.
Royal Society, Tasmania.
Astronomische Gesellschaft, Leipsig.
Society of Sciences, Cherbourg.
Society of of Telegraphic Engineers.
Public Library, Cape Town.
Academy of Sciences, Bologna.
Physical Society, Berlin.
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The University, Upsala.
Norwegian Meteorological Institute.
United States Government.
United States Bureau of Navigation.
American Philosophical Society.
American Association for the Advancement of Science.
American Academy of Natural Sciences.
Orleans County Society of Science.
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Franklin Institute.
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Editor of the Athenæum.
Editor of the Quarterly Journal of Science.

Editor of *Nature*.

Editor of the *English Mechanic*.

Editors of *Silliman's Journal*.

Editor of the *Revue Scientifique*.

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Dr. A. Wieler.
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M. A. Wijkander.
M. Winnecke.
Dr. R. Wolf.
Prof. C. A. Young.
Dr. E. Young.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

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